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JOHN ELLARD GORE.

HECTOR MACPHERSON JR.

FOR POPULAR ASTRONOMY.

Death has been busy in the past few months in the ranks of the leading astronomers. In May last Astronomy was bereft of Sir William Huggins. His death was followed in rapid succession by those of Prof. Schiaparelli and Dr. Galle, the veteran German observer. Now they have been followed by the sudden and unexpected death of Mr. J. E. Gore, one of the ablest of our present-day astronomers.

John Ellard Gore was born at Athlone, Ireland, on June 1, 1845. He was the son of the Rev. John Ribton Gore, Archdeacon of Elphin, and was educated privately and at Trinity College, Dublin, where in 1805 he obtained his Diploma in Engineering with high distinction. Three years later he was appointed assistant engineer in the Government Public Works Department, serving on the construction of the Sirkend Canal in the Punjab. While so employed, his attention was drawn to astronomy, and his interest in the sublime science was probably developed by the fine climate of the Punjab. He began to study the heavens, not only with the naked eye and binocular, but also with telescopes of three or four inches aperture and with this equipment he studied attentively double and variable stars. His early observations are especially valuable in regard to suspected variables, as his estimates of stellar magnitudes were very accurate. In a small book, published in 1877, he utilized most of his observations in India. In that year he returned to Ireland on a two year's furlough and in 1879 he definitely retired on a pension from the Government service. He was then free to devote all his attention to his favorite study, the science of astronomy. He never held any official position as an astronomer and received no honorary degrees; yet his astronomical work takes high rank among the observers of his day and generation. His life like that of the German astronomer, Olbers, a century ago, is a brilliant example of what an amateur may accomplish in astronomy.

On his return from India, Mr. Gore went to reside with his father at Ballisodare, in County Sligo, and on the death of the Archdeacon a few years later, he removed to Dublin, where the greater part of his uneventful life was spent. He was unmarried and was of a quiet and retiring disposition, devoting himself for many years to his astronomical work as a writer and observer. On the evening of Monday, the 18th of July, a cruel stroke of fate deprived modern astronomy of one of its most gifted leaders. While crossing Grafton street, Dublin, Mr. Gore was run over and fatally injured by a car, and thus astronomy is bereft of a great student and a noble worker in much the same manner as chemistry was deprived of one of its noblest pioneers M. Curie, of radium fame, by a similar accident four years ago. Mr. Gore was in his sixty-sixth year at the time of his death.

Mr. Gore was a Fellow of the Royal Astronomical Society, a member of the Royal Irish Academy, the British Astronomical Association and the Société Astronomique de France. He was a frequent contributor to the leading scientific periodicals of the day.

The present writer corresponded largely with Mr. Gore during the past few years and remembers with pleasure the kindly assistance, which the distinguished astronomer gave him, in the preparation of "Astronomers of To-Day." Mr. Gore was kind enough, a month before his untimely death, to read over the proof sheets of another of the writer's books. He was kindness itself and an attentive and interesting correspondent. Ireland has lost one of its two greatest astronomers, the other being Sir Robert Ball, who, it is to be hoped, will be long spared to adorn the science of Astronomy.

Mr. Gore's astronomical work may be conveniently grouped into two departments (1) observational and statistical and (2) literary and speculative. In observational astronomy he accomplished much valuable work, notwithstanding the fact that he never possessed a large telescope. His work was accomplished by the unaided eye, the binocular and small telescopes. His favorite field of work was variable stars, He presented to the Royal Irish Academy in 1884 a "Catalogue of Known Variable Stars," containing reference to 190 stars, augmented afterwards to 243 when he revised the catalogue some years later. He also published a "Catalogue of Suspected Variable Stars." In 1884 he discovered a star closely south of ρ Cygni, varying in about 131 days. It is now known as

W Cygni. In 1885 he detected his second variable, S Sagittæ, with a field-glass; and on December 13 of the same year he detected the famous variable, U Orionis, which was for some time supposed to be a temporary star and was known as Nova Orionis. In 1890 he detected X Herculis, while he showed the probable variability of η Arietis and λ Draconis. The large number of estimates and comparisons of star-magnitudes which he amassed, eventually led him to his recognition of a separate class of variable stars, which he designated as "secular variable stars," because their variations are performed in long periods of time. He published in 1904, in his "Studies in Astronomy," a notable paper on "The Secular Variation of Starlight," giving a list of the stars suspected and known to be variable. Many of these variations were detected from an examination of his own estimates, others by a comparison of his estimates with those of other observers of standing.

Mr. Gore also attentively investigated the distribution of variables and he found a tendency to cluster into groups. "Thus, in and near the constellation Corona Borealis there are five; near Cassiopeia's chair, five. In Cancer there are four in a limited area. Near η Argus there are several and in a comparatively small region in the northern portion of Scorpio there are no less than fifteen variable stars."

In 1901, Mr. Gore was one of the independent discoverers of Nova Persei, the bright temporary star which in that year astonished astronomers. He noted his discovery thus—"A great new star in Perseus, between β Persei and δ Persei; preceding a little north of ν Persei." The discovery was made by Mr. Gore on February 22, twenty-two hours after it was first seen by Dr. Anderson at Edinburgh. Until November 1901, Mr. Gore observed the new star on every available evening. In 1902, he pointed out the unusual brilliance of the star Betelgeuse or α Orionis, finding it on Oct. 16, 17 and 26 of that year to be equal to Capella in brightness. Recently Mr. Gore's eyesight began to fail and he did not observe so frequently as formerly.

In the study of double stars, Mr. Gore earned a well deserved reputation. From 1879 onwards, he devoted his attention to binary stars and computed the orbits of more than twenty, investigating also the inclinations of their orbits to the plane of the Galaxy. In 1890 he presented to the Royal Irish Academy a catalogue containing reference to 59 stars. Some of his calculations were of deep interest, especially his

contention that in the case of δ Cygni the companion might be regarded as a giant planet in the sunlike stage of its existence.

To the study of the Milky Way, Mr. Gore devoted a great deal of attention. He verified the conclusion arrived at by Proctor and Schiaparelli, that the stars visible to the unaided eye show a tendency to crowd on the Galaxy. But his investigation took the stars magnitude by magnitude and showed that the stars of each magnitude taken separately aggregate on the Galaxy. He found that, of 32 stars brighter than the second magnitude, twelve lie on the Milky Way or on faint nebulous light connected with it. Of those brighter than the third magnitude, 33 stars out of 99 lie on the Galaxy and of those brighter than the fourth, 73 out of 262. Now the area covered by the Galaxy does not exceed one seventh of the entire heavens, so the percentage of bright stars on the Galaxy is one and a half times that due to its area. Mr. Gore also investigated all the stars in the charts of Heis and Harding down to the eighth magnitude, only to confirm his previous work. He also directed attention to the apparent connection between the lucid stars and the nebulous light of the Galaxy. On October 26, 1889, Mr. Gore noted as follows in his observing book. "North of α Cygni and near ξ and ν Cygni, the nebulous light of the Milky Way seems to cling round and follow streams of small stars in a remarkable way; numerous small 'coal sacks' and rifts are visible, in which comparatively few stars are to be seen in the binocular. This remarkable observation, a brilliant example of what may be done with the binocular if handled as Mr. Gore handled it, was afterwards confirmed by Dr. Max Wolf's photographs of the same region.

As a writer on astronomy, Mr. Gore held one of the foremost places in Brittain. Not only was he busily employed in contributions to British and foreign astronomical periodicals, but he published a large number of works. A list of his books may be given here—

"Southern Stellar Objects for Small Telescopes"	1877
"Planetary and Stellar Studies"	1888
"The Scenery of the Heavens"	1890
"Astronomical Lessons"	1890
"Star Groups"	1891
"The Astronomical Glossary"	1893
"The Visible Universe"	1893
"The Worlds of Space"	1894

"The Sidereal Heavens" Section of the Concise Knowledge Astronomy	1898
"The Stellar Heavens"	1903
"Studies in Astronomy"	1904
"Astronomical Essays"	1907

In addition, he translated in 1894 Flammarions "Popular Astronomy." In his books are to be found most of his original investigations. Some of his works are more fragmentary than others, being collections of articles and sketches on astronomical subjects. One of them, "Star Groups," is a guide to the heavens, quite the most admirable production of its kind I have seen. "The Scenery of the Heavens," too, is in its way a masterpiece. I am inclined however, to assign the place of honor to "The Visible Universe." It is not only the greatest of Mr. Gore's books; it is one of the greatest books in astronomy which have appeared in recent years, and as a resumé of our knowledge of the construction of the heavens, is unrivalled.

Some of Mr. Gore's speculations are highly suggestive and may be noticed here. In "The Scenery of the Heavens" he speculates on the origin of the galaxy. He considered it to be the remains of a great vortex-ring, which, originating in a nebulous mass, has partly broken up. "After the isolation of this vortex-ring in the ether, its disintegration could of course, be caused only by the mutual attractions of its component members, and from the general appearance of the Milky Way, it seems highly probable that its present condition is the result of gravitation between its members."

In "The Visible Universe," Mr. Gore speculates on the origin and construction of the heavens. He discusses the theories of Wright, Kant, Lambert, Herschel, Struve and Proctor and after a discussion of their views and of the opinions of other astronomers, he concludes that our universe is limited in extent and brings forward evidence to support his conclusions.

"It may be proved mathematically," he writes, "that, supposing the number of stars infinite and equally distributed through infinite space, if there is no extinction of light in the ether, the whole heavens would shine with the brightness of the Sun. Such is clearly not the case. On the clearest nights the amount of light afforded by the stars is on the contrary very small, and the comparative blackness of the background on which they are scattered is sufficiently obvious. The number of the *visible* stars cannot, therefore, be infinite." He

next shows that the hypothesis of light extinction is untenable and that the limited number of the visible stars is only to be explained on the theory "that all the stars, clusters and nebulæ visible in our largest telescopes form one vast system, which constitutes the one visible Universe."

But Mr. Gore supposed that our finite Universe was not the only one and that there exist other external Universes. Regarding the Solar System as a system of the first order, he calls the Galaxy a system of the second and so on to the third and fourth Universes of Universes. In "The Stellar Heavens he says, "We need not go farther than the third order, for if light would probably take millions of years to reach us from an external universe of the second order, surely the altogether inconceivable distance of systems of the third order would sufficiently account for their light not yet having reached us, although traveling towards our Earth for possibly billions of years!"

Mr. Gore made a calculation of the possible distance of a hypothetical external universe of the second order. Assuming the distance of the nearest of these universes to be proportional to that separating the Sun from α Centauri, he found it to be 520,149,600,000,000,000 miles, a distance which light with its enormous velocity of 186,000 miles per second would require, ninety millions of years to traverse."

Overwhelmed with the marvels disclosed in this calculation, with the revelation of Infinity which this calculation gave him, Mr. Gore closed his investigations with the following beautiful thought:—"The numbers of stars and systems really existing, but invisible to us, may be practically infinite. Could we speed our flight through space on angel wings beyond the confines of our limited universe to a distance so great that the interval which separates us from the remotest fixed star might be considered as merely a step on our celestial journey, what further creations might not then be revealed to our wondering vision? Systems of a higher order might then be unfolded to our view, compared with which the whole of our visible heavens might appear like a grain of sand on the ocean shore—systems perhaps stretching to Infinity before us and reaching at last the glorious 'mansions' of the Almighty, the Throne of the Eternal."

A strong religious vein ran through all of his writings and speculations. Like Schiaparelli, whom he has not long survived, he was impressed and overwhelmed by the Glory of the

Universe and the Mystery of things. In "The Visible Universe" he writes thus on the luminiferous ether, "Perhaps some time in the coming century, science with its advancing strides may give to mankind some slight insight into the constitution of this incomprehensible fluid; but at present we can only say with the Psalmist, 'Such knowledge is too wonderful and excellent for me: I cannot attain unto it,' and to most of us this knowledge will never come until we find ourselves afloat at last on the shoreless ocean of eternity." Mr. Gore has already solved the problem. He has passed beyond the earthly shadows.

WHAT IS THE ETHER?

OWEN ELY.

Since the time of Newton, physicists have seen the need of assuming an ether to explain "action at a distance," or the passage of electric and magnetic forces through empty space. Though these phenomena have been thoroughly studied through experimental research, comparatively little work has been done to deduce from the laws and facts at our disposal the real properties and conditions of the ether. The concepts of an ether have generally been so mystical and vague that scientists have shunned the task of correlating or confirming them. But more recently science has realized the importance of this realm of inquiry. Lorentz, Larmor, Thomson, Kelvin, Lodge and others have sought some basis of experimentation and have attempted to build complete and consistent theories. Results are slowly accumulating, more definite hypotheses are being formulated, and perhaps a few more decades will give us a fairly complete knowledge of this understratum of nature,

The first important theory of the ether was developed by Green and others, in the early part of the nineteenth century. The ether was regarded as a kind of incompressible jelly, easily set a-quiver by the motions of the molecules and able to transmit this motion, through its vast bulk, to the ends of space. And yet, for any motions of matter other than the molecular, the ether was thought to act as a perfect fluid. This provision was necessary to limit the ether to transverse vibrations. Owing to the increasing demands which new discoveries in

optics made upon the theory, it was abandoned and now retains only historic interest.

One of the most prominent theories which have been brought forward, was that connected with Maxwell's electro-magnetic theory of light. The ether was assumed to be a turbulent fluid, the particles of which oscillate, revolve, or in some way change their condition, causing the rapidly alternating "polarizations" which Maxwell used to explain his conception of the electro-magnetic wave. Sir William Thomson, in the Philosophical Magazine for June, 1853, gave the theoretical demonstration to prove that the reversing of an electric charge produces a "polarization," the same in kind as that which constitutes a light-wave. Later, Hertz actually proved the identity. But "polarization" is still little more than a name, and there is yet some discussion as to whether it involves any bodily displacement of the ether.

The ether having been regarded as a solid and a fluid, it remained to treat it as a gas. This was attempted by several, among them Mendeleef, the chemist. But the results did not seem very satisfactory. Evidently, the ether needed properties of each state of matter, solid, fluid and gaseous. Rigidity and elasticity of some sort were required, that light should travel in a straight path; the freedom of movement of a perfect fluid was necessary, since apparently there was no friction between matter and ether; and finally its inertness, its failure to affect matter of itself, pointed to a lack of cohesion or activity among its particles. For these reasons, apparently, modern physicists have generally ceased trying to picture ether in terms of matter, but rather are inclined to explain matter in terms of ether. Thus Professor Osborne Reynolds, who has worked upon his theory for many years, regards the ether as a system of finely-packed grains of which it would take some $112 \cdot 10^{17}$ to make up an inch, and whose mean free path is $4 \cdot 10^{-11}$ of their diameter. These round, hard grains are piled up like billiard-balls through the universe, but here and there is a crack or separation, and this vacuum is matter! The encounters of the cracks make up the phenomena of the cosmos.

Larmor's concept seems somewhat similar, for he regards electrons as "nuclei of permanent etherial strains in rapid motion." Kelvin and his school lay emphasis upon an explanation of the ether's perfect elasticity. Kelvin's famous theory of the ether makes its elasticity "due to rotational motion —intimate, fine-grained motion throughout the whole etherial

region—motion, not of the nature of locomotion, but circulation in closed curves, returning upon itself—vortex motion, of a kind far more finely grained than any waves of light or any atomic or even electronic structure. If the elasticity of any medium is to be explained kinetically, it follows, as a necessary consequence, that the speed of this internal motion must be comparable to the speed of wave propagation; that is to say, that the internal squirming circulation, to which every part of the ether is subject, must be carried on with a velocity of the same order of magnitude as the velocity of light."*

On this assumption, Sir Oliver Lodge calculates that the ether must possess $3 \cdot 10^{11}$ kilowatt centuries per cubic millimeter, or "the energy of a million horse-power station working continuously for forty million years!" Kelvin's theory is based upon the principle of the gyroscope as appled to fluids, which thus imitate solids. Many experiments have been made to demonstrate the strange properties of liquids or flexible solids when in rapid motion. A silk cord moving swiftly over a pulley, has become rigid and viscous; and waves set up on the cord travelled with its velocity, thus standing still. This shows why "the speed of (the ether's) internal motion must be comparable to the speed of wave propagation." To show the elasticity of spinning bodies, Lord Kelvin made a spring balance out of gyrostats.† The "hardness" of fluids in motion is illustrated by a stream of water under strong pressure, which will resist blows from a sword.

Kelvin's gyroscopic theory, however, is useful only in providing a fluid ether with the elasticity of a solid. And does it not seem futile to evolve an ether from the properties of matter, when those properties in turn depend upon the ether? The action of the gyroscope involves the inertia of matter: yet Professor J. J. Thomson and others are now inclined to explain inertia as an effect of the electromagnetic energy which a body carries about with it in the ether. But if inertia is not an "inherent" property of matter, but rather a phenomenon involving ether, why should it be used to endow the ether-particles? A second ether would be necessary to account for the inertia of the first. Indeed, it is so difficult to build up any hypothesis without the use of inertia and the laws of motion, that we may be compelled at last to resort to another

* Lodge, The Ether of Space (1909), pp. 102-3.

† Address to Section A of British Association at Montreal, 1884.

ether. But since that is merely shifting the ultimate problem, we must do our best to gain a simpler theory.

Again, it is difficult to conceive how the particles, however "fine-grained" their gyroscopic motion, would avoid being in continual contact and collision, destroying the permanency of the system and producing a gaseous state. Motion in exact circles would be broken up and the gyroscopic principle no longer at work. At least it is difficult to explain how any kind of motion can be provided for the crowded particles of ether other than some irregular, chaotic vibration like that of a gaseous molecule. The particle cannot be compared to the vibrating molecule in cohesive solids, nor to the revolving electron, for both must be held in their systematic orbits by forces acting through a medium. The difficulty of making the ether circulate about a fixed center, in order to make it gyroscopic and elastic, seems about as large as the original problem itself.

There are, perhaps, other ways of explaining the properties of rigidity and fluidity in the ether. If matter be regarded as merely a crack or strain in the ether, the latter need not be fluid, since there could be no such thing as "friction" between matter and ether. Then if the ether be thought of as quite densely packed, with particles in orderly rows, columns, and tiers, it might not be difficult to imagine how a single pulse of light emanating from a molecule should continue, like a missile having inertia, to follow the straight line upon which it was started. For light is made up of waves in several planes, which we may regard separately. Motion in one plane cannot pass into another, and if the tier of particles in which the wave started is not disturbed by passing matter, the wave would remain in one plane. But what prevents the wave from spreading about its plane, instead of holding a straight path? This, too, must be a result of the regular arrangement of the particles, so that the wave moves as a uniform interaction among the particles of several rows, confined to these rows alone, like a moving pendulum. Thus the simple pulse from a molecule in the Sun would reach our Earth practically unchanged. The size of an object, then, alters not because all the mingled pulses reach the eye diminished in size, but because the number of pulses entering the eye, undiminished, depends upon the square of the distance. Were the former the case, and if the light-wave spread out like a sound-wave as it emanated from a source, some change in the structure of

wave would take place, and it would be difficult to explain the rectilinear propagation of light. The structure of the ether could scarcely be as perfect as pictured, but if the particles be of a very small order of size compared to the light-wave the result should be about the same. Only by this means, indeed, could we imagine the tubes, or parallel rows traversed by each wave, as stretching away from the source in *every* direction. This description, crude as it is, may serve to show that the theory of the ether has not yet been exhaustively worked, while it points out some of the difficulties in an adequate explanation of the actual transverse wave in ether.

Having reviewed some of the general theories of the ether, it will be interesting to look into the methods which have been used to gain facts and figures in regard to the ether, and to see what tangible results have been reached.

A modern school of physicists have derived a value for the elasticity of the ether from the formula $V = \sqrt{\frac{K}{D}}$ or $K = V^2D$. The density of the ether has been calculated on the assumption that the electron is a differentiated portion of ether, but of equal density. The linear dimension of the electron is about 10^{-12} or 10^{-13} mm., and if its mass is not an effect of its magnetic field, the various estimates based upon different experiments all yield the same result, about 10^{12} c.g.s. units. V^2 we know to be $9 \cdot 10^{20}$, so that $K = 10^{33}$, the figure generally agreed upon by some of the greatest scientists. The estimate is of little value, however, except as it may direct further inquiry. The structure of the electron must be investigated before its density can safely be used to indicate that of the ether.

Deductions have been made as to the structure of the ether from the computed velocities of the various wave-lengths of light in space. But they are of questionable value, for at present it is still a moot question whether or not the various waves have exactly the same velocity. However it is an important line of research and will certainly yield us some knowledge of the ether. We are too acustomed to treat light as a whole, not as to particular wave-lengths. Lord Rayleigh has said, "We have no means of identifying a particular wave so as to determine its rate of progress. What we really do in most cases is to impress some peculiarity, it may be of intensity, or of polarization, upon a part of an otherwise continuous train of waves, and determine the velocity at which the peculiarity travels." Rayleigh used the formula

$U = \frac{d(kV)}{dk}$ to express the possibility that V, the velocity of a particular wave-length, may differ from U, the group velocity. Now the work of Nordman on Algol has tended to show that red rays (about .68μ) were sixteen minutes ahead of the blue (about .43μ). Pritchard's estimate of Algol's parallax is .0556″, or about 61 light-years. Dr. C. V. Burton, using these data and Rayleigh's formula (L. E. D. Philosophical Magazine, Dec. 1909) has set up equations representing the conditions of periodic motion in the ether, in order to show that the velocity of propagation is a function of the wave-length and and that no absorption need occur in the ether. The laws of dispersion are applied to strings and by combination of these to three-dimensional space. The nature of the formulae developed by him leads to the conclusion that "The system (of ether-particles) has a structure on a scale not infinitely minute compared with the wave-length. Though we may conceive the electro-magnetic vibrations of the æther to be executed in a manner widely different from anything occurring in these simple mechanical models, we may yet attempt to form some idea of the coarseness of structure of the æther which could suffice to account for such dispersions as Nordmann and Tikhoff have thought to be indicated by their observations." The formula deduced by Dr. Burton from Rayleigh's equation is $U = V_\infty (1 - \pi^2 b^2) 2\lambda^2$. When this is applied to the figures given by Nordmann and Tikhoff above, the result is only $1.7 \cdot 10^{-8}$ cm. and $3.1 \cdot 01^{-9}$ cm. respectively, for b, "a linear magnitude which expresses the coarseness of structure of the æther." But the electron is said to be only 10^{-13} cm. in diameter; and since the ether-particle should be of a lower order of size than the electron, this indicates that the observations are unreliable or the formulæ wrong. The fact that the two observations disagree in the ratio of nearly one to thirty has furnished an argument against the reality of dispersion. But if dispersion is proved to exist it must be attributed to the structure of the ether, since Lebedow has shown that it cannot be accounted for by the presence of any known substance in space (for example, hydrogen at low pressure), which would absorb light enough to make Sun and stars invisible.

In 1874 Clerk-Maxwell calculated the pressure of light to be about 1/23000 of a dyne per sq. cm. for full sunlight; and a quarter of a century later Lebedow, Nichols and Hull verified

the theory, the two latter reaching a figure within one per cent of Maxwell's estimate. Lately Professor Poynting has measured the backward thrust of the light-wave as it leaves its source. When we have worked out a definite picture of the electro-magnetic wave, this primary fact should be very useful in explaining its genesis and the relation of the electron to the ether surrounding it.

It has been assumed, during the above discussion, that no friction exists between matter and ether; but the question was by no means settled until recent years. Many experiments were tried during the past half-century, but none were conclusive until Michelson made his famous experiment in 1887. This seemed at first to show that the ether is stagnant about the Earth, or that it does not rush by us and through us at the rate of the Earth's motion. Two half beams of light, one sent to and fro along the line of the ether drift, east and west, and the other across the line of drift, were re-united and should have shown a displacement in the bands of the spectrum of one part in a hundred million—the square of the ratio of the speed of the Earth to that of light. A change of one part in 4000 millions could have been detected in the apparatus but no change was seen. The explanation was first suggested by Professor G. F. Fitzgerald, of Trinity College, Dublin, and was later developed by Professor H. A. Lorentz of Leiden. The cohesion of the materials in the apparatus by which the measurements were made, was probably due to electric charges in the atoms. The cohesion was then less great across the line of the Earth's motion than along it, for the reason that the charges become currents on account of the Earth's motion, and the attraction between the parallel currents is less than in the currents which follow each other in the same line of motion. Therefore, although the light-wave probably increased in velocity across the line of the Earth's motion, the stone slab across which it travelled increased in length proportionately.

An interesting and original experiment was undertaken by Sir Oliver Lodge to settle the question in a different way. Two large steel discs an inch apart were rotated at enormous speed while a beam of light was divided by a semi-transparent mirror and the two halves were sent in opposite directions around and between the discs until they met in a telescope. After eliminating the sources of error, it was found that the images were exactly coincident and that hence no ether had

been caught up in the motion of the steel discs.

Perhaps nothing has contributed so much to the possible development of a theory of the ether as the electron theory, which has done so much to reduce phenomena to the inter-play of the electro-static, magnetic, and inductive forces of charged atoms. These forces, together with matter, which may be simply their source in the ether, and gravitation, which is probably an electro-static effect, constitute the whole problem of the ether. The ultimate task is to explain them as varieties of motion in the fundamental stuff.

To sum up, it is apparent that the problem of the ether, the greatest enigma of all time, cannot be solved by one group or generation or class of scientists. It claims the work of specialists in many fields. While each may see the task from his viewpoint alone, it is worthy of attack from many standpoints. To analyze and classify a nearly infinite variety of phenomena to reach the root-causes of nature, requires the genius of the investigator. To arrange the data in the most logical relationships requires the work of the theorists. To condense and reduce these relations to the simplest and most elegant form the brain of the mathematician is necessary. To appreciate the ultimate significance of those factors which the others use but as the material of their building, the philosopher is final critic. And to make the results of all the others of interest and value to the human race as a whole, the interpreter must picture them in simplest phrase and most apt illustration.

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SOME RECENT DISCOVERIES IN COSMICAL EVOLUTION.*

T. J. J. SEE

* Address to the Popular Educational Society of San Francisco, August 26, 1910.

In a brief time available tonight I shall not attempt elaborate arguments respecting my recent investigations, many of which are of mathematical character and of considerable length, and are given in my new work, "Researches on the Evolution of the Stellar systems," Volume II, 1910; but shall content myself with a popular summary suitable for a general audience.

In the first place it should be remarked that, although the New Cosmogony is the newest of the sciences, the Old Cosmogony dates back to the time of the Greek philosopher Parmenides, who was the revered teacher of Plato. On the whole the the progress of Cosmogony throughout the centuries has been slow, very slow indeed; yet it has never entirely ceased, except during the Middle Ages.

Eudoxus and other writers among the Greeks believed that the heavenly bodies revolve in crystalline spheres, and had been set revolving in circles because the circle is a perfect geometrical figure, and was therefore preferred by the Deity for the orbits of the stars. After Kepler's discovery of 1609, that the planetary orbits are elliptical, it was necessary to modify these views to correspond to the true laws of nature. Both Kepler and Newton wondered at the roundness of the planetary orbits, but were unable to assign the cause of this remarkable law of our system. No physical cause for the circularity of the planetary orbits was assigned prior to 1796, but in that year Laplace explained this property of the planetary paths by supposing that the planets had been detached in the form of rings which afterwards condensed into globular masses. A similar explanation of the circularity of the satellite orbits was also put forth at the same time, so that all these bodies were supposed to have been detached by a gently accelerated rotation.

The doctrine that the planets and satellites were thrown off by rotation has been current for more than a century, but it is now definitely proved to be erroneous, and has been quite abandoned by astronomers since the publication of my researches of the year 1908, showing that the roundness of the orbits is to be explained by the secular effect of a resisting medium, and by no other cause whatsoever. Laplace's theory is therefore finally overthrown, and what is known as the capture theory substituted in its place.

It is shown by accurate calculations based on Babinet's criterion that the planets never were any part of the Sun, but were formed in the outer parts of the solar nebula, and have since neared the Sun, and had their orbits rounded up and made smaller and smaller. The satellites, including the terrestrial Moon, have likewise been captured and added on to the planets which now govern their motions. The result of the capture theory is essentially a new nebular hypothesis, which explains all the known phenomena of our system, even the

retrograde motion of the outer satellites of Jupiter and Saturn.

In the old nebular hypothesis it was supposed that a nebula is a fluid mass in equilibrium under conditions of hydrostatic pressure, so that the rotation of the central nucleus transmitted pressure outwards and aided in throwing off a ring of nebulous matter from the periphery; in the new nebular hypothesis there is no fluid pressure from the center outwards—the bodies develop as independent nuclei in the nebula, and drift towards the larger centers of attraction. Thus the planets are added on to the Sun from without, and the satellites added to their several planets. When the planets began to develop in our primordial nebula they were at great distances from the Sun, and hence nearly as far away as the comets are now.

Accordingly it is evident that our planets and comets were originally related. The comets which come to us from a great distances are the survivals from the outer shell of the primordial nebula—the matter of the inner part of the nebula having been eaten out to produce the Sun and planetary systems. This accords with the appearances of the other nebulae, which are shown to be excessively rare and of vast extent. It has taken us three centuries to find out the real meaning of the comets; but the light now thrown on the connection between planets and comets is worth all the labor which has been bestowed upon this difficult subject.

The repulsion of the matter in the tails of comets from the Sun is easily explained; for it is now shown that the nebulae themselves are formed from fine dust expelled from the stars by the action of repulsive forces, and as the comets are survivals of our primordial nebula, the repulsion of the volatile elements in the tails of comets is not remarkable. This dust drifts about hither and thither and finally collects into clouds called nebulae. It is shown by astronomical photography that the whole background of the sky is more or less covered by a faint haze of nebulosity. When this nebulosity collects into dense clouds we have nebulae, and they begin to settle down and develop into cosmical systems. Accordingly it is now shown that the stars produce the dust which collects into nebula, and finally develops into stars. So that the stars form the nebulae and the nebulae in turn form the stars; and the universe is governed by a cyclical process, apparently of endless duration. The result of this whole investigation is a greatly improved theory of the starry heavens.

PLATE XXVII

ISOGRAPHIC PROJECTION OF THE NORTHERN CELESTIAL HEMISPHERE.

The nebulae are represented by dots, the clusters by crosses.

One of the points of greatest interest attaches to the discovery that the congregation of the nebulae away from the Milky Way, with maximum accumulation near the poles of the Galaxy, is the result of the action of repulsive forces, under which fine cosmical dust expelled from the stars is driven as far away from the Milky Way as possible.

Heretofore astronomers have had no general theory of the origin and distribution of the nebula. As long ago as 1785 Sir William Herschel noticed a tendency in these cloudlike masses to gather in the regions of the heavens away from the Milky Way, and this law was further confirmed by Sir John Herschel about 1845; but no explanation of the facts thus established has been forthcoming.

It is well known that I have been occupied with the study of Repulsive Forces for about ten years, and have at length shown that the nebulae are formed from dust expelled from the stars, which in turn are formed from the condensation of nebulae. The tendency of the nebulae to avoid the Milky Way is due to the expulsion of the nebula-forming dust from the stratum of stars constituting the Milky Way and therefore the clouds produced by the condensation of this dust naturally accumulate in the regions remote from the Galaxy. As the nebulae develop into stars surrounded by systems of planets, it seems probable that they are gradually drawn back into the starry stratum, by the attraction of the stars lying in the plane of the Milky Way. One of the greatest and most fundamental facts established by the telescopic explorations of the Herschel's on the arrangement of the sidereal universe thu a natural and simple explanation in accordance with known laws.

It is thus clear that a complete theory of cosmical evolution involves the action of both attractive and repulsive forces, and should enable us to explain all classes of the heavenly bodies,—namely, Suns, and stars, double stars, single stars surrounded by planetary systems, habitable planets revolving about the fixed stars in nearly circular orbits, and rotating on their axes like the planets of the solar system; comets, variable stars, new or temporary stars, and finally the development of multiple stars and clusters. Accordingly Laplace's original nebular hypothesis, implying the formation of bodies by the throwing off of rings, is incorrect and now quite abandoned by astronomers.

The most important physical cause at work to modify the

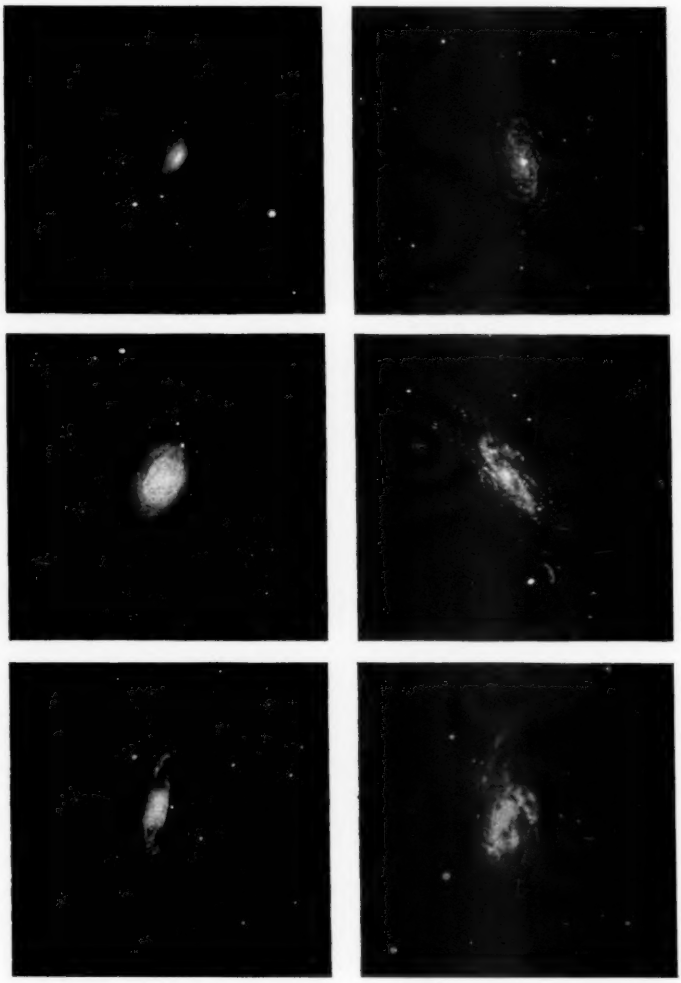
motions of the heavenly bodies is the action of a resisting medium. The variable stars, especially the cluster variables, are due to planets revolving in such a medium and blazing up at the time of perihelion passage, and thus the periods are very regular. New stars are due to collisions with large planets; hence the outbursts are of short duration.

The discoveries made during the last two years have enabled me to reduce cosmogony to a new basis, by which it now becomes an exact science. The development of a new science is always of profound interest. In this connection I will merely point out how remarkably every part of the new Nebular hypothesis, or Capture Theory, supports every other part; so that the whole work is knit together into a harmonious whole of such irresistable strength that it cannot be overthrown. The craters on the Moon show the size of the small bodies originally composing our nebula; for these craters are proved to be indentations due to the impact of satellites against the Moon's face, and not volcanic action, as was long believed. The new theory explains the rotations of the planets on their axes, and their obliquities, as well as the motions of the satellites and the roundness of their orbits. The comets, as already remarked, are the surviving fragments from the outer shell of the ancient nebula which formed our system, the matter of the inner parts having been eaten away in forming the Sun and planets. Thus the planets and comets were originally related, and the relationship is further illustrated by the connection of the Asteroids with the short-period comets captured by Jupiter. It is shown by the researches of mathematicians that both of these classes of small bodies have been captured and thrown into their present positions by the disturbing action of this giant planet. A nebula might be not very inappropriately described as a cluster of comets so dense as to shine with a hazy light.

One other result of deep interest is the increased extent of our solar system, which is shown to be of vast dimensions. Neptune's orbit is so round that it cannot possibly be the outermost of our planets, and good reasons may be adduced for thinking that some of the unseen planets still revolving on the outer borders of our system may yet be discovered by observation, although the search will be difficult, owing to the great distance and faintness of the Sun's light in these remote regions of space.

I will add just one more concluding announcement, namely,

PLATE XXVIII



SPIRAL NEBULAE PHOTOGRAPHED AT LICK OBSERVATORY

H. I. 205, Ursae Majoris
M 81, Ursae Majoris
M 65, Leonis
H. I. 56-57 Leonis
H. I. 199, Ursae Majoris
M 66, Leonis

that the planets now shown to revolve about the fixed stars are inhabited by some kind of intelligent beings, so that life is unquestionably a general phenomenon of the universe. It is well known that the late Professor Newcomb expressed similar views in an address delivered at the dedication of the Flower Observatory, Philadelphia, in 1897. The proof is now much more complete than ever before; and men of science will have to admit life to be general on the countless worlds revolving about the fixed stars, or else concede that life upon the Earth is an accident and a mistake, existing for hundreds of millions of years in direct violation of the laws of nature, which no philosopher could possibly admit; for this would be a *reductio ad absurdum* more convincing than those developed in the science of geometry and taught in the best schools and universities of the world. The life flourishing on the Earth and believed to exist also on Mars and Venus is but a drop in the Pacific Ocean compared to that flourishing on the thousands of billions of habitable worlds now definitely proved to revolve about the fixed stars.

U. S. Naval Observatory,
Mare Island, California, Aug. 20, 1910.

DRIFTING OF THE SUN'S FAMILY.

ARTHUR K. BARTLETT.

The part of the heavens, toward which it is believed the Sun with its entire family of planets, comets, satellites and meteor-streams, including, of course, our own Earth, is moving with great velocity, is situated at this season directly overhead about 6 o'clock in the evening, and at a later hour a little farther toward the northwest. This is one of the most interesting and important localities in the firmament to astronomers, toward which their attention and observation have been directed for many years past.

The greatest fact which modern astronomy has revealed is that our whole solar system is now journeying toward the constellation Lyra in the northern heavens, and the greatest of the unsolved problems of astronomy is when, where, and how this journey began, and when, where, and how it will end. This journey is unceasing and unchanging, and is believed to

be at the rate of twelve miles per second, or about 300,000,000 miles in a year. The question as to whence we came and whither we are drifting is one of vast importance, and is still engaging the attention, as it has in the past, of the leading astronomers of the world, for in connection with it is involved the even greater question regarding the structure, extent and boundary of the universe.

If we look up to the sky, directly overhead, just after sunset we shall see a star of the first magnitude known as Vega, which is located in the constellation Lyra, the Harp, and is plainly visible throughout most of the evening. This star, next to Capella, is the brightest north of the equator, and is famous as being the one which, in 12,000 years, will occupy the important position of the "Pole-star," and will be known by that name in the future. The star shines with a bluish-white light, and may be easily recognized, as it is the most conspicuous of any star visible near the zenith at this season.

It is toward this star, or rather the group to which it belongs, that our Earth and the solar system are believed to be moving, and this point in the heavens is known to astronomers as the "apex of the Sun's way." During the last 120 years many astronomers, with ever increasing accuracy, have sought to determine the point toward which our Sun, the Earth and all the other planets are moving. For many years the result of investigations was that our system is traveling toward the constellation Hercules in the northern sky. But more recent and careful measures lead to the conclusion that the point is located in the nearby constellation Lyra. This point is nearly four degrees south and slightly east of the bright star Vega, the variations between final measurements, maxima and minima, of all who have attacked the great and highly complex problem being as much as seven degrees,

Owing to the "solar drift" in space, the orbit of our Earth, instead of being an ellipse, is really of a corkscrew shape, the axis of the "corkscrew" being in the direction of the constellation Lyra. The great star-cluster in Hercules, containing over 6,000 visible suns, is not very far away from that part of the sky which we are approaching, and it is possible that our system may form a distant part of one of its encircling wisps of star-strewn nebulous matter, so that in this case we may eventually be drawn into the gigantic cluster.

Most astronomers agree as to the general direction of the Sun's motion, but owing to the motion of the stars them-

selves, there is not yet an exact agreement regarding the amount or direction of this motion. In a general way we may say that if an observer looks up to the heavens a little south west of the zenith, on a clear evening at this season, he may correctly imagine our Earth and the great system to which it belongs, as moving toward the stars he there sees presented to his view. This motion has been going on since the creation, and will probably continue for unknown ages in the future.

It is true, as a recent writer in POPULAR ASTRONOMY has well remarked, "That since the 'beginning' we, with the Sun, have been steadily speeding on and on through interstellar space without once meeting or passing a single lonely star, brings home to our realization as no other consideration can, the amazing amplitude of cosmic space, the completeness of the isolation of each star from all others, and the supreme magnificence of the scale of the stellar universe."

Quite recently a new and ingenious theory has been advanced by two astronomers who have attempted to prove that the millions of stars composing our immense universe are moving in two parallel streams, traveling in contrary directions, and situated in opposite regions of the heavens, but their novel ideas have not been confirmed and have received little attention from astronomers who regard them at present as nothing more than an interesting speculation which does not admit of a practical demonstration, though it is possible that careful and long-continued observations in the future may produce evidence in its favor.

The direction of our motion is indicated by the fact that the stars in that part of the heavens toward which we are traveling are observed to spread out and get farther apart, while those we are leaving in the opposite part of the heavens close up and gradually approach each other, just as in walking through a forest the trees in front of us are seen to open out, while those in the rear appear nearer together as we leave them behind. But at present it is not known whether we are moving in a straight or curved path, and if in the latter it is so great that it cannot be determined. Many stars which have a "proper motion" as it is called, appear to be moving in a perfectly straight path through the sky. Among them is the faint star known as "No. 1830 Groombridge," which is believed to be rushing through space at the rate of over 200 miles per second—a velocity so great that the combined attraction of all the masses in the universe cannot stop this star in its swift

and solitary flight over the firmament. It is known to astronomers as the "Runaway Star," but there are some other stars that are believed to be travelling even more rapidly, and none of them exhibits any indications of moving in a curved path.

It is interesting to remark that the motion of the solar system plays an important part in the shifting panorama of the heavens. Not only do the stars move onward, but the Sun, moving also, carries us continually northward, so that our point of view is ceaselessly changing, and looking out from the flying Earth, we are like people on a ship which is passing by a squadron of other ships. Their evolutions cause them to appear in constantly changing relations to one another, and at the same time our own motion, shifting the line of sight, produces other changes of view, which increase the complexity of the apparent movements. In short, we are reminded of the remarkable resemblance of the universe to the modern conception of an atom, in which the restless corpuscles are speeding in all directions, so that an infinitesimal being, inhabiting one of those corpuscles, would see the other corpuscles shaping themselves into constellations that would be as unenduring as are the figures that the poetic imagination traces among the stars.

The famous German astronomer Mädler, over fifty years ago advanced the theory that our Sun and all the stars—which are also Suns—are moving in a great orbit around the star Alcyone located in the Pleiades, a prominent cluster mentioned in the Bible, and known as the "Seven Sisters," six of which are plainly visible to the naked eye and may be seen at this season just above the eastern horizon about 8 o'clock in the evening. But Mädler adduced no evidence in support of his views, which were not generally accepted by astronomers. His ingenious theory was exploded many years ago, and astronomers do not at present recognize any particular star as the center around which all the other stars revolve, though it is possible that such a center exists somewhere in the universe.

The theory that the solar system is revolving around a central Sun was first suggested by Thomas Wright, of England, in 1750, and later Mädler supposed that he had discovered the exact center of this motion; but it is not thought by astronomers that sufficient evidence exists to support this belief, and all that can be said to be established at present is, that the Sun with its great family of revolving worlds, is rushing through space toward a point in the constellation Lyra, a familiar group of stars located in the northern heavens, and which may be seen to good advantage at this season in the early evening.

Battle Creek, Mich.

EARLY OBSERVATIONS OF THE SOUTH POLAR CAP AND BELTS OF SATURN.

H. C. WILSON.

In looking over the files of the *Monthly Notices* of the Royal Astronomical Society to see if the blue polar cap of Saturn had been noticed by the observers, 28 and 56 years ago, I find references to observations of the south polar cap by Mr. Lassell, in 1852 (vol. XIII, p. 16), Rev. W. R. Dawes, in 1852 (vol. XIII, pp. 17-19), Mr. W. F. Denning, in 1880 (vol. XLI, p. 83), Mr. Henry Pratt, in 1884 (vol. XLIV, pp. 86 and 408), Mr. A. C. Ranyard, in 1883 (vol. XLIV, p. 442) and Mr. N. E. Green, in 1884-5 (vol. XLV, p. 401). None of these gentlemen appear to have seen the cap with anything like the distinctness with which it appears in the 60-inch reflector at Mount Wilson, but I think there is no question but that some of them saw the same marking.

As many of the readers of POPULAR ASTRONOMY have reflecting telescopes and may wish to compare the views of Saturn which they get during the next two or three months with the descriptions of earlier observers, the following quotations may be of interest.

Mr. Lassell observed with his 20ft. reflector, aperture 4ft., in the clear atmosphere of Valetta, on the Island of Malta. In a letter to Mr. Sheepshanks, Nov. 25, 1852 he describes the belts of Saturn as seen with power 650 as follows:

"First then, referring to Mr. De la Rue's diagram and reckoning southward from the southern portion of the obscure ring where it crosses the ball, there is the brilliant zone about equal in breadth to the sum of the two bright rings at their narrowest part. Secondly, the principal ruddy belt extending from 7° to 28° south latitude. Thirdly, a white zone about 5° broad, not, however, so brilliant as first zone, nor so uniform and well defined in its brightness. Fourthly, a yellowish ruddy belt terminating sharply about 45° in. Fifthly an extremely narrow dark blue or bluish-green belt. Sixthly, another light zone, but of a deeper shade, and marking the commencement of the bluish-green portion. Seventhly a lighter narrow blue belt passing through the 60th degree. Eighthly, a still deeper shaded light zone. Ninthly, a sharply defined, very dark blue

belt, a little above the 70th degree, and encircling the pole. Of this belt about three-fourths of the whole circle can be seen, including within it the pole itself, marked by a lighter coloured spot of about 20° diameter."

Rev. Dawes uses the following expressions: "The two belts on the ball just south of the equator are pretty well defined; but the most southern is not much darker than the cap-like belt which covers the south pole.

"The belt-like cap which covers the whole of the southern hemisphere is considerably less dark near the south pole, agreeing in this respect with the appearance last year.

"The dark shading which has for some time surrounded the south pole appears to me to have formed itself into a more distinct belt than was visible in September. I believe the whole or very nearly the whole of this belt is seen, the middle of its breadth being about 12° from the pole, which is comparatively light. On November 30th the whole region within 30° or 40° of the pole was noticed to have a light greenish blue tint, the tendency to green being more decided than I had before observed."

Rev. Dawes observed with a refractor of 8½ feet focus and magnifying power 460. He does not appear to have caught the actual polar cap but has mingled its color with that of the belts next north of it.

Mr. W. F. Denning used a Browning-With reflector of 10 inches aperture, powers 450 and 500. After describing the equatorial belt and those next south of it he says: "Yet further south of the bright belt there comes a series of very dark belts. The one immediately contiguous to the pole exhibits the greatest intensity of shading and is, in fact, the darkest region of the disk, and there is a fainter band dividing this from the light belt. At the pole itself I first suspected a bright cap, but renewed observations, made on several nights when the air was exceptionally steady and the planet free from the tremulous motion which so effectually destroys good definition, showed that the immediate pole, though lighter than the dark belt surrounding, was much enveloped in shade." Mr. Henry Pratt, observing with a With speculum of 8.15-inch aperture, uses language which describes the polar cap and the contiguous belt pretty well but the excellent sketch which he gives indicates that, either the cap extended to latitude about 45°, or he took the edge of one of the more northerly belts for that of the cap. He says:

"The belts of the two hemispheres are, in general arrangement, usually similar and symmetrical. On both sides of the equator similar alternations of colour and proportion are usually seen. For some distance on each side of the equator extends a zone which is usually free from any markings whatever showing only a creamy yellow tint. At a latitude of roughly about 10° occurs a strong belt, narrow, sharply defined on its equatorial side, but diffused on its polar side, and gathered in places into wispy knots and curved markings. The colour of this I always see as vandyke brown. This narrow belt is the deepest tint of all the markings on the globe, and when our atmosphere is not perfectly translucent, it is almost or quite the only detail which can be seen. So far as I can understand, this narrow belt was the subject of discussion at the last meeting (of the Royal Astronomical Society). The polar side of this brown belt and its wispy curves is softened into a narrow zone of cream tint, which again merges into one of very pale rose-madder, which ends in a moderately sharp boundary, about latitude 25° This is followed by a zone a few degrees in width and of cream tint; and about latitude 40° commences a double belt, very pale rose-madder in tint, the space between then being of cream tint, and the belt highest in latitude being the broadest of the two. In turn this is followed by a zone of cream tint until the polar cap of the bluish white is reached."

In describing his drawing made in 1884 when the south pole of Saturn was in view Mr. Pratt says: "The polar region, lying entirely within view, is without any defined boundary, being blended very softly with the zone on its north, with which it is contrasted by its darker tone; while on its farther margin it is oppositely contrasted with the still darker southern limb. Its colour is bluish gray."

Mr. Ranyard in speaking of the narrow belt which was in question in 1883, and which he observed with an 18-inch reflector Sept. 4, 1883, says, "I distinctly saw the narrow belt; it still appeared to me bluish-gray, decidedly darker than the south polar cloud-cap, from which it was separated by an interval of more than its own breadth." The diagram, however, which he gives would indicate that what he called the polar cap was much larger than that which is now visible.

Mr. Green gives a sketch which shows the polar cap and adjacent belt almost exactly as they appear now. He used an 18-inch reflector with powers of 250 to 400. His descrip-

tion of the belts is as follows:

1. South polar cap, dark gray.
2. Very faint extension of the gray of the pole, slightly yellow.
3. Broad band of yellowish-gray light.
4. Broad belt of slightly deeper colour.
5. A well marked narrow dark gray belt.
6. Very narrow belt of yellowish light, irregular in outline.
7. The darkest belt on the ball, colour warm gray.
8. Equatorial light, very bright in the center.
9. The edge of the dusky ring, the shade of which is increased by a dark belt on the northern side of the equatorial light.

As quoted in Proctor and Ranyard's *Old and New Astronomy* p. 625, Mr. Browning, a maker of reflecting telescopes, describes the colors of Saturn's disk in the following manner in terms of the pigments which he employed to get the nearest approach to the observed tints: "The rings are yellow ochre shaded with the same and sepia; the globe yellow ochre and brown madder, orange and purple, shaded with sepia; the pole and the narrow belts situated near it on the globe, pale cobalt blue.

THE DISTRIBUTION OF NEBULAE AND GLOBULAR STAR CLUSTERS.

E. A. FATH.

The writer has had occasion recently to draw some charts showing the distribution of the nebulæ and globular star clusters. The main points, as brought out in the three charts, have been generally known for some time, but the peculiarities of this distribution are so striking that they may be of interest to others. No discussion will be attempted.

The charts represent the sky on Mercator's projection, the right ascension and declination being indicated. The curved line is the great circle of the Milky way, assuming the North Pole of this to be at $\alpha = 12^h\,40^m$, and $\delta = +\,27°$. This point is indicated by a cross near the center of the charts. The South Pole of the galaxy is similarly indicated near the left.

The material for the charts has been taken from Dryer's *New General Catalogue of Nebulæ and Clusters*; Robert's *Celestial*

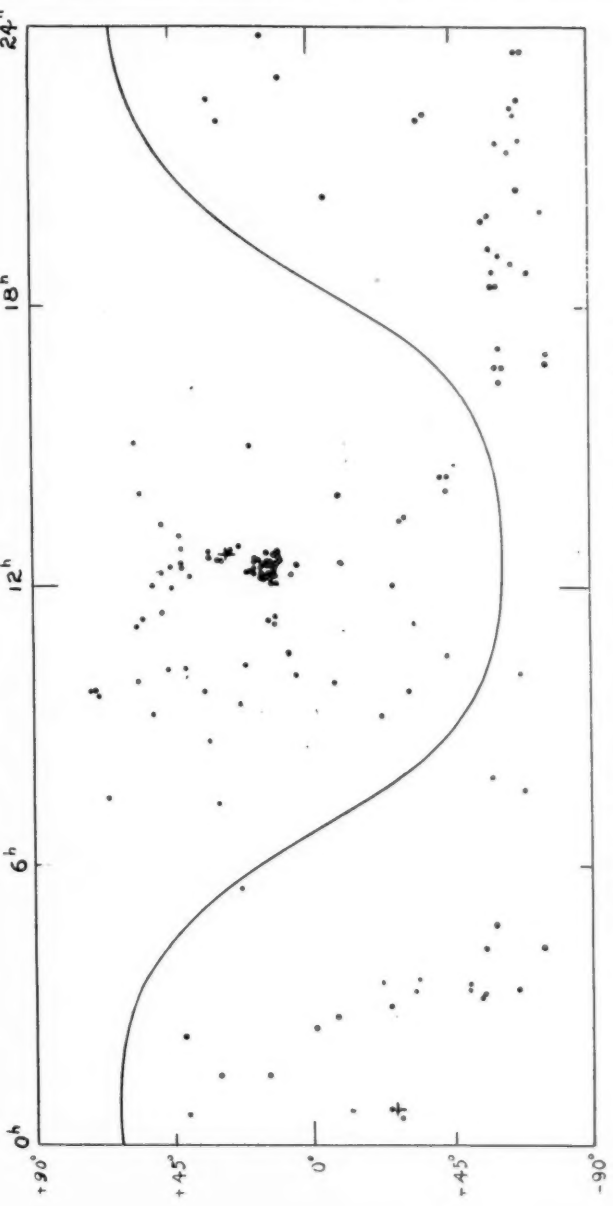


CHART 1. Showing the Distribution of the Spiral Nebulæ

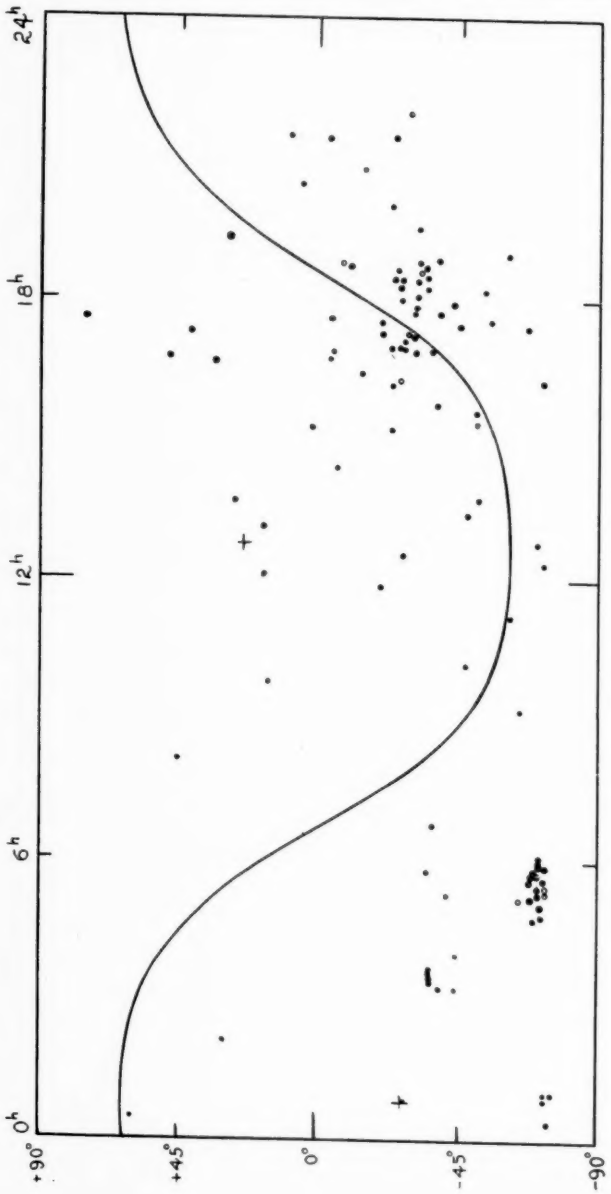


CHART 2. SHOWING THE DISTRIBUTION OF THE GLOBULAR CLUSTERS.

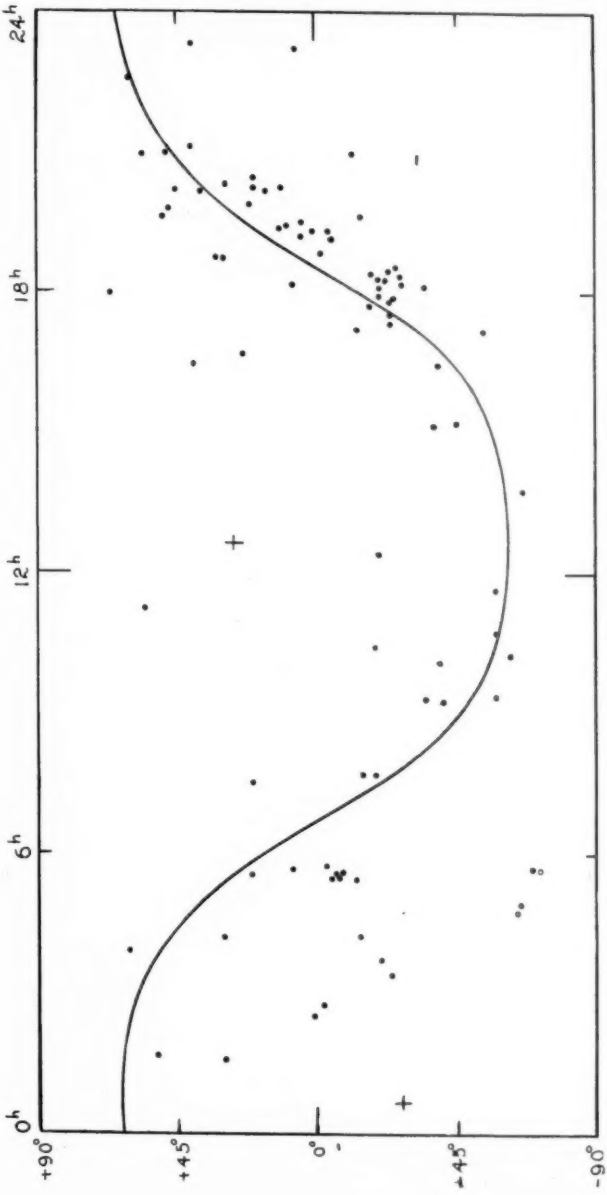


CHART 3. SHOWING THE DISTRIBUTION OF NEBULÆ WHICH FROM THEIR SPECTRA ARE BELIEVED TO BE GASEOUS.

Photographs, vols. 1 and 2; *Lick Observatory Publications*, v. 8; Scheiner's *Populäre Astrophysik*; and *Annals of Harvard College Observatory*, v. 60, Parts 6 and 8. This material is by no means homogeneous, but there seems little reason to believe that the defect will materially alter the facts given below.

In the chart showing the distribution of the Spiral Nebulæ one thing is particularly noticeable, namely the clustering around the poles of the Milky Way. This is more pronounced in the northern hemisphere than in the southern. The nebulæ charted are only the larger ones, where the spiral nature is certain. A plate exposed sufficiently long to obtain images of stars down to the 16th or 17th magnitude, if taken near the North Pole of the Milky Way, will show many objects, sometimes scores, which have exactly the appearance of minute spirals, as indicated by their usually elliptical outline, but which are too small to show distinctly the spiral arms. Until these are shown one cannot be absolutely sure of their character. If all such suspicious objects were inserted, some regions of the chart would be a solid mass of black. Professor Wolf, of Heidelberg, found 1728 such nebula in a region of only 30 square degrees near the north galactic pole.

The spiral nebulae, so far as investigated, give for the most part absorption spectra. The only possible explanation seems to be that the spirals are clusters of stars. If this should ultimately prove to be the case, then these are very different both in form and distribution from the globular clusters. The chart of the latter shows a great group clustering around the region of the Milky Way near 18^h right ascension. The remainder are for the most part in or near the Magellanic clouds, those apparently detached pieces of the Milky Way in the southern heavens. To discriminate between small and somewhat irregular clusters and globular clusters is sometimes difficult, but for this class the material is undoubtedly more homogeneous than for the nebulae.

The third chart shows the distribution of the nebulae which from their spectra are believed to be gaseous. These are most decidedly condensed toward the plane of the Milky Way. There are, of course, many thousands of nebulae whose spectra we know nothing about, so this distribution refers only to the brighter objects of this class.

So far as the writer knows, there is no satisfactory theory of the development of the visible universe to explain these peculiarities of distribution. What the future has in store we cannot predict, but surely it is not unreasonable to hope that sometime we shall know.

Pasadena, Cal. Sept. 29, 1910.

THE RELATION BETWEEN THE SEPARATION AND THE MAGNITUDE OF VISUAL DOUBLE STARS.*

R. G. AITKEN.

In carrying out the survey of the sky to secure data for statistical studies relating to double stars I have been impressed with the fact that the number of close pairs discovered far exceeds the number of pairs separated by moderate distances. More than 70 per cent of the 3500 pairs so far discovered in the course of this work have measured angular distances of 2″ or less, and about 50 per cent, distances of 1″ or less.

This is obviously due in large part to the facts, (1) that the survey is carried on systematically, pains being taken to examine every star as bright as 9.0 B. D. magnitude on nights good enough to realize nearly the full power of the telescope, and (2) that a larger percentage of the easier pairs have been discovered by earlier observers. But the question arises whether the closer double stars are not in reality more numerous than the wider ones, and further, whether the numbers do not show a progressive increase with diminishing angular separation, even when parallax† is taken into account.

It was in the latter form that the question was put to me by Dr. Campbell about a year ago.

When the double-star survey mentioned is completed, data will be at hand for a thorough discussion of this question, but at that time the best material available for its investigation was Burnham's "General Catalogue of Double Stars within 121° of the North Pole," supplemented by the lists of new pairs published later in the L. O. Bulletins.

A count was made under my direction by the Secretary of the Observatory of all the double stars in Part I of Burnham's Catalogue and the pairs listed according to angular distance and the assigned magnitude of the brighter component. Stars fainter than 9.5 magnitude, or wider than 5″.0, were not included, and no attention was paid to those of Sir John Her-

* *Lick Observatory Bulletin* No. 176.

† It is clear that we should expect to find a much greater number of close pairs than of wide pairs assuming an approximately uniform distribution in space of binary systems and neglecting parallax.

schel's stars whose distance he only estimated.* To the figures thus obtained I subsequently added the stars Hu 1201-1327 and A 1251-1900. Table I shows the result, the rows giving the numbers for each 0″.5 of the angular separation to 5″.0, the columns the numbers according to magnitude. The first column includes all pairs for which the principal component is as bright as 6.0 magnitude, the next three those for which the brighter component lies between 6.1-7.0, 7.1-8.0, and 8.1-9.0 respectively; and the fifth column, those in which both components are as faint as 9.1.

It is, of course, true that such a classification is merely approximate, as the magnitude estimates are those of the discoverers, as a rule, and are by no means systematic. However, it will appear that this does not materially affect our main conclusion.

TABLE I.

DOUBLE STARS UNDER 5.″01 AND HAVING ONE COMPONENT AS BRIGHT AS 9.5 MAGNITUDE IN BURNHAM'S GENERAL CATALOGUE OF DOUBLE STARS.

	5.5 Mag.	6.5	7.5	8.5	9.5	Total	Total corrected for parallax.†
Under 0.″51	43	88	257	609	279	1276	1048
0.51-1.00	51	110	260	599	236	1256	1119
1.01-1.50	43	70	220	502	157	992	1079
1.51-2.00	37	66	159	405	145	812	717
2.01-2.50	25	51	160	308	93	637	495
2.51-3.00	32	42	122	266	72	534	469
3.01-3.50	24	48	81	237	66	456	306
3.51-4.00	30	30	94	161	52	367	221
4.01-4.50	17	35	69	188	39	348	188
4.51-5.00	15	28	60	167	25	295	167
Total	317	568	1482	3442	1164	6973	5809

Inspection of the table shows that under each magnitude, as well as in the column headed "Total," the number of pairs increases with decreasing angular distance. That the increase is less marked when we pass from the second row (distance 0″.51 to 1″.00) to the first (distance under 0″.51) is only what might be expected from the far greater difficulty of detecting the very close pairs. It will also be noticed that the number of double stars with distances under 5″.0 increases rapidly

* No appreciable error is introduced by the omission of the John Herschel stars, for, as I have found by actual comparison with the sky, very few indeed of them are as bright as 9.0 magnitude, except the very wide pairs, 15″ to 60″ or more

† The column 9.5 is not included in the summation given in the final column.

with the numerical increase of magnitude, up to the magnitude 8.5 inclusive. The falling off at magnitude 9.5 is due simply to the fact that the stars fainter than 9.0 have not been systematically examined by double-star observers.

To correct our results for parallax we may assume that Kapteyn's average parallaxes represent the *relative* distances of the stars of different magnitudes. The absolute parallaxes, it is obvious, are of no importance in this connection. To reduce the observed values to what they would be if all of the double stars were removed to the distance of the average 8.5 magnitude star, we may assume that the angular separation of the stars in the first row averages 0″.3 and in the following rows 0″.75, 1″.25, etc., and divide these values by the factors taken from the following table:

Magnitude	Factor
5.5	2.8
6.5	2.0
7.5	1.4
8.5	1.0

Summing the stars after this division, we obtain the last column of the table. The stars of 9.5 magnitude are not included in this summary because we know that the figures given do not at all adequately represent the numbers of pairs of this magnitude.

To check the results obtained by this investigation I have recently made an accurate count* of the double stars under 5″.0 distance in the region of the sky north of +36° declination, omitting a small area in the second quadrant of Right Ascension which has not yet been fully examined in my survey. The sky area examined includes 44634 stars of 9.0 B. D. magnitude or brighter.

Table II shows the distribution of the double stars in this area according to angular distance and to the B. D. magnitude of the stars. The observer's magnitude estimates are thus eliminated, and only the known systematic errors of the B. D. magnitudes affect our results. I have not considered it necessary in this preliminary investigation to take these into account.

The next to the last column in this table shows the results corrected for parallax, *i. e.*, the numbers of double stars of the

* The count was made directly from the charts used in the survey of the sky; hence it includes every pair under 5.″0 and brighter than 9.1 B. D. magnitude (both the previously known pairs and those newly discovered) that were visible with the telescopes of this observatory.

various distance classes if all were removed to the distance of the average star of the 8.75 magnitude. It was assumed that the average magnitude of the pairs in the first column is 5.5 and the average separation of the stars in the first two rows combined, 0″.3, the mean values of magnitudes and of angular distances being taken for the rest of the table. The parallax factors employed are:

Magnitude	Factor
5.5	3.1
6.25	2.4
6.75	2.0
7.25	1.7
7.75	1.4
8.25	1.2
8.75	1.0

These factors suit Kapteyn's parallax values of the I type stars as well as those for the II type.

The final column of Table II is derived from the last column of Table I by dividing by the factor 2.68, in order that the results of the two tables may be compared directly. It will be seen that the more accurate magnitude (and distance*) values of Table II bring out more clearly than the figures of Table I the marked increase in the number of double stars as the angular distance diminishes, and, moreover, the progressive nature of this increase. This general conclusion is, however, also to be derived from Table I, and seems therefore to be definitely established. †

From this table we may infer either that the number of close visual stars (under 5″.0) is relatively greater among the brighter stars, or that a larger percentage of the latter has been discovered. If the second explanation is the true one, the progressive increase in the number of double stars as the angular separation diminishes is still greater than that shown by Table II, for it is only the very close and difficult pairs that will have escaped detection.

Table II also shows the increase in the number of double stars of every distance class under 5″.0 with increasing numerical magnitude, but the increase is not as rapid as that of the

* In forming the second table the distances used are the most recent ones that I could find. They are therefore all referred to approximately the same epoch.

† That Mr. Gavin J. Burns (*Jour. B. A. A.*, 12, 245, 1902) arrived at a different conclusion from his investigation of the Struve and Burnham stars is due to the incompleteness of the data these afford.

TABLE II.

DOUBLE STARS UNDER 5″.0 IN THE ZONE +36° TO +90°.

	6.0 Mag. or less	6.1 to 6.5	6.6 to 7.0	7.1 to 7.5	7.6 to 8.0	8.1 to 8.5	8.6 to 9.0	Total	Total corrected for parallax	Corrected total from Table I divided by 2,68
0″.25 or less	7	8	13	16	24	40	38	146	558	391
0.26-0.50	7	7	32	37	62	94	157	396		
0.51-1.00	16	12	16	31	50	85	164	374	449	418
1 01-1.50	10	14	19	22	45	71	105	286	343	403
1.51-2.00	13	8	16	26	39	47	75	224	212	268
2.01-2.50	5	5	7	16	25	29	73	160	211	185
2.51-3.00	12	5	11	19	28	45	56	176	128	175
3.01-3.50	5	1	8	8	16	21	50	109	93	114
3.51-4.00	7	5	7	13	21	26	38	117	69	83
4.01-4.50	3	4	4	7	14	19	46	97	71	70
4.51-5.00	2	0	7	3	12	25	35	84	35	62
Total	87	69	140	198	336	502	837	2169	2169	2169

TABLE III.

	6.0 Mag. or brighter	6.1 to 6.5	6.6 to 7.0	7.1 to 7.5	7.6 to 8.0	8.1 to 8.5	8.6 to 9.0	Total
Double Stars under 5″.01	87	69	140	198	336	502	837	2169
B. D. Stars	937	893	1741	2678	4910	10132	23343	44634
Ratio	1:11	1:13	1:12	1:14	1:15	1:20	1:28	1:20.6

total number of stars after we pass the magnitude 7.0. This will appear from Table III. The second line in this table is formed on the assumption that the magnitude distribution of the stars in the area examined is the same as that in the Northern hemisphere as a whole. Since the stars in this area are 44 per cent of all those to 9.0 B. D. magnitude in the Northern Hemisphere, the assumption seems legitimate.

The fact that one star in about 13½ of those as bright as 8.0 B. D. magnitude in this area is a double star under 5″.0, while among the stars between 8.0 and 9.0 magnitude the ratio is only 1 to 25, is exceedingly interesting and possibly significant. It will be recalled that observations by Campbell, Frost and others show that one star in 5 or 6 among those with well determined radial velocities is a spectroscopic binary, and that the known spectroscopic binaries, excluding the variable stars, have an average magnitude of 3.9,

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NEW DOUBLE STARS, AND DOUBLE STAR WORK.

E. D. ROE, JR.

The following new double stars have been lately found and measured with my 6½-inch Clark refractor and Gaertner micrometer. On account of their faintness the measures of distance should be received with some caution, as well as the estimates of magnitude. The effort required to see two faint near stars as separated produces the same physiological sensation of closeness as the effort to separate two much closer but brighter stars, and this seems to influence the measures of pairs that are very faint for a 6½-inch aperture, if they are relatively close. Many of the measures must be regarded as only estimates with the micrometer, even where they seem to be consistent. The pairs were either identified as B. D. stars or referred to the nearest B.D. star and the Durchmusterung positions were corrected for precession to 1910. The date given with each pair is the time of discovery.

ρ 48 $15^h\ 27^m\ 26^s$, $46°\ 1'$

$1^m\ 28^s.8$ preceding and 3′.97 north of B. D. + 46° 2075. ($10^m.2$, $10^m.5$) 19 July 1910.

1910.653	222.3	9.05
.657	220.6	8.62
.667	222.0	8.02
1910.659	221.6	8.56

ρ 49 B. D. + 37° 2796

$16^h\ 42^m\ 27^s$, 37° 14′ ($9^m.0$, $10^m.5$) 26 August, 1910.

1910.687	96.5	9.79
.693	96.1	10.36
.696	95.2	10.77
1910.692	95.9	10.31

ρ 50 B. D. + 39° 3520

$18^h\ 42^m\ 22^s$, 39° 59′ 26 August 1910 A,B ($9^m.8$, $10^m.7$)

1910.653	281.3	3.50
.663	281.0	3.61
.693	280.6	4.40
1910.670	281.0	3.84

1910.653

A,C ($10^m.0$)	133.6	32.24
A,D ($10^m.6$)	250.	110.7
A,E ($11^m.0$)	195.	90.5
A,F ($11^m.8$)	130.	40.
C,F	114.	10.

The observations of D, E, F are merely estimates made with the eye or micrometer. The component F was first detected with the university 8-inch Clark refractor. It was afterwards seen but with more difficulty with the 6½-inch.

ρ 51 B. D. + 39° 3523

$18^h\ 42^m\ 40^s$, 39° 36′ 9 September, 1910. A,B ($8.^m8$, $10^m.3$)

1910.693	186.6	74.94

B,C (10^m6)

1910.693	292.5	6.00
.707	293.1	5.62
.713	293.2	6.80
1910.704	292.9	6.14

The pair B,C was confirmed 14 September, with the 8-inch.

ρ 52 B. D, + 33° 4139

$21^h\ 0^m\ 8^s$, 33° 17′ ($10^m.2$, $10^m.5$) 17 September 1910.

1910.716	76.6	7.14
.748	76.4	7.13
1910.732	76.5	7.14

ρ 53 B. D. +33° 4146

$21^h\ 0^m\ 54^s$, 33° 24′ ($9^m.0$, $10^m.7$) 17 September, 1910. In the same field with ρ 52.

1910.716	179.5	6.70
.748	177.4	6.89
1910.732	178.4	6.79

ρ 54 B.D. — 0°4355

$22^h\ 20^m\ 35^s$, — 31′ ($9^m.8$, $10^m.4$) 7 October, 1910.

1910.770	198.9	7.74
.773	198.6	7.75
.780	199.3	7.63
1910.774	198.9	7.71

ρ 55 $22^h\ 21^m\ 33^s$, + 12′ (10^m, $10^m.5$)

7 October, 1910. $2^m\ 41^s.7$ following, and 1′.84 north of B. D. — 0°4363.

1910.770	45.8	4.54
.773	46.2	4.11
.780	46.0	4.13
1910.774	46.0	4.26

The last two pairs are both inside the triangle of Aquarius of which ζ Aquarii nearly marks the center.

ρ 56 $23^h\ 34^m\ 52^s$, 47° (10.3, 10.5) 12 October 1920.

1910.786	84.1	8.35
.790	85.0	9.43
1910.788	84.5	8.89

$16^s.1$ preceding and 3′.08 north of B. D. 46°4114. Seven brighter stars inside of 175″ distance, most of them preceding it.

ρ 57 B. D. + 46° 4118.

$23^h\ 35^m\ 38^s$, 47° 3′,12 October 1910. (8.8, 10.6)

1910.790	111.4	13.34

ρ 58 $23^h\ 47^m$, 46° 30′ (rough place) (9.6, 9.8)

12 October, 1910.

1910.786	63.0	5.28
.790	64.6	5.70
1910.788	63.8	5.49

I think this a B. D. star. Its exact place will be determined later.

ρ 59 B.D. + 45°33

$0^h\ 9^m\ 9^s$, 46° 8′ (9, 9.2, 9.3) 12 October, 1910

A,B	1910,786	210.8	8.21
	.790	213.1	10.98
	1910.788	212.0	9.59

B, C will be measured later.

In the center of an equilateral triangle of faint companions each at about 35″ distance from it, and one of them nearly south. Another faint comes about twice as far south.

Incidentally while waiting for conditions suitable for work on new stars, some new measures of old pairs have been made, as follows:

G. C. 426 η Cassiopeiae

1910.713	239.3	6.25
.716	242.8	6.32
.745	241.9	6.49
1910.725	241.5	6.35

7717 ζ Herculis

1910.657	148.0	1.38
.663	148.3	1.45
.667	148.6	1.30
1910.662	148.3	1.38

9374 β Cygni

1909.726	54.4	35.11
1909.730	54.1	34.18
1910.723	54.1	34.87
1910.060	54.2	34.72

8692 α Lyrae, A,B

1909.865	164.6	54.58
1910.713	164.7	53.72
1910.289	164.6	54.15

A,E

1910.713	39.3	112.74

11021 Espin 100

1909.919	155.4	3.44

A faint comes 12^m at 340°, 31″.33. A more distant one at about 117°, 70″. These are not noted in the G. C. Not much weight should be given to this measure as it is only for one night and served chiefly for the identification of this pair.

Good position angles have been obtained with the 6½-inch for such pairs as ϕ Ursae Majoris, ϵ Equulei, and β Delphini. While much work should be left to large apertures, still it is desirable

for one to get the most he can out of the means which he has at hand. The following measures of difficult and close pairs were made by me with the 6½-inch last year and show what can be done with a small telescope when the stars are bright enough to be seen.

6955 ζ Bootis

1909.366	139.9	0.64
.380	139.6	0.66
.400	139.7	0 65
1909.382	139.7	0.65

Though not separated the two discs were distinctly seen.

7368 γ Coronae Borealis

1909.420	119.7	0.71
.435	120.1	0 73
.438	118.5	0.71
1909.431	119.4	0.72

7717 ζ Herculis

1909.435	154.5	1.11
.438	154.8	1.19
.448	154.8	1 35
1909,440	154.7	1.22

This may be compared with the measure made this year The motion is well shown.

9605 δ Cgni

1909.576	291.4	1.65
.583	290.5	1.63
.586	291.2	1.62
1909.582	291.0	1.63

10533 λ Cygni

1909.576	52.5	0.73
.580	53 6	0.72
.583	52.8	0.72
1909.580	53.0	0.72

During the summer I got the Director of the Holien Observatory, Dr. Peck, to let me take the 8-inch objective home and clean it. I adjusted it in the cell and on the tube after cleaning it and it easily separated ζ Bootis, even with a power of 200. This year the discs are just in contact or barely separated at moments as seen in the 6½-inch.

I estimate the present distance to be about 0″.68. The 8-inch also separated ζ Sagittarii, a good performance considering its closeness and its low position in the sky. I expect

it to separate λ Cassiopeiae and γ_2 Andromedae. These though not separated are well shown by the 6½-inch the discs of the former at least being quite distinct. The 8-inch easily shows two more stars in ε Lyrae, which can be also seen with more difficulty with the 6½-inch. A number of faint stars about and near to the ring nebula in Lyra can be seen with both glasses. The cluster M13 is fine in the 8-inch. Of course the 8-inch is superior in separating power, and gives about 1.5 as much light as the 6½-inch. Nevertheless the 6½-inch is a jewel, and I take this occasion of expressing my gratitude for the feeling which prompted Mr. Lawes to offer it to me, and of acknowledging my great obligation to him for the many letters he has written giving me the benefit of his experience and advice with respect to observing, and for the kind interest he has always taken, and the helpful encouragement he has given me in my work.

Syracuse University, October 13, 1910.

PLANET NOTES FOR DECEMBER, 1910.

Mercury will be in conjunction with the Moon on December 2. It will reach its greatest heliocentric latitude south on December 11, and will be south of the ecliptic until December 30, at which time it crosses the ecliptic. It also reaches its greatest elongation east of the Sun on December 24, so that it will be visible in the south west after sunset, and will set about an hour and a quarter after the Sun on the day of greatest elongation.

Venus will be in conjunction with the Moon twice during the month, on December 1, and also on December 31. It will, however, remain so close to the Sun during the month as to be invisible.

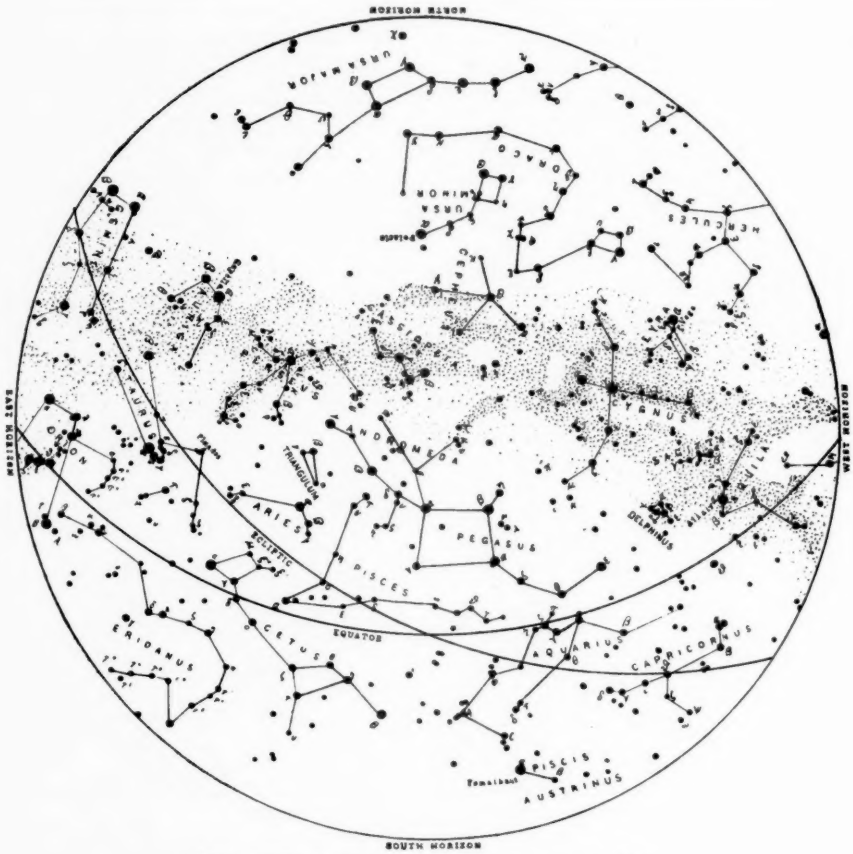
Mars will rise during the month of December from an hour and a half to two hours before the Sun and may be seen in the eastern sky at that time. Since it is so far away it is not in a particularly favorable position for observation. It is approaching the Earth again. It crosses the ecliptic going southward on December 31.

Jupiter will be in conjunction with the Moon on December 25. It is visible in the east two or three hours before sunrise, and will be the morning star during the month.

Saturn will be very favorably situated during the month of December. It will rise at, or a little, before sunset, and consequently will be high enough by ten o'clock for good observations. Interest is added to this usually most interesting object, because of the polar cap that was noticed recently through the large reflector at Mt. Wilson.

Uranus continues to move east in Sagittarius at the rate of about one minute a day. It crosses the meridian at an altitude of about 25° from the southern horizon at this latitude, and is rather low for observing.

Neptune will be moving westward slowly in the constellation Gemini during the month. It will cross the meridian a little after midnight.



THE CONSTELLATIONS AT 9:00 P. M. NOV. 1, 1910

Occultations visible at Washington.

Date 1910	Star's Name	Magnitude.	IMMERSION. Washington M.T. h m	Angle f'm N. °	EMERSION. Washington M.T. h m	Angle f'm N °	Duration. h m
Dec. 9	336 B Aquarii	6.3	3 3	65	4 19	229	1 16
10	54 B Ceti	6.3	7 39	117	8 10	164	0 31
12	Saturn		2 54	74	3 48	226	0 54
14	192 B Tauri	6.1	10 52	49	12 5	268	1 13
14	*V* Tauri	4.2	17 3	109	17 49	237	0 46
14	72 Tauri	5.4	17 24	77	18 13	270	0 49
17	*c* Geminorum	5.5	15 46	80	16 50	313	1 4
19	57 B Leonis	6.5	15 15	95	16 29	324	1 14
20	46 Leonis	5.8	12 27	179	12 55	226	0 28
23	*k* Virginis	5.7	18 12	135	19 37	307	1 25
24	*m* Virginis	5.4	16 23	108	17 37	330	1 14

Phenomena of Jupiter's Satellites.

Central Standard Time.

1910	h	m					h	m			
Dec. 1	16	49	I	Ec.	Dis.	Dec. 17	16	37	III	Tr.	In.
2	16	10	I	Sh.	Eg.	18	15	20	I	Tr.	Eg.
	16	53	I	Tr.	Eg.	20	17	27	II	Oc.	Re.
4	16	7	II	Sh.	Eg.	24	16	49	III	Sh.	In.
	17	39	II	Tr.	Eg.		16	58	I	Ec.	Dis.
9	15	50	I	Sh.	In.	25	15	5	I	Tr.	In.
	16	39	I	Tr.	In.		16	17	I	Sh.	Eg.
10	16	12	I	Oc.	Re.		17	18	I	Tr.	Eg.
11	16	5	II	Sh.	In.	26	14	38	I	Oc.	Re.
	17	47	II	Tr.	In.	27	15	31	II	Ec.	Dis.
16	17	43	I	Sh.	In.	29	15	18	II	Tr.	Eg.
17	15	3	I	Ec.	Dis.						

Note.—In., denotes ingress; Eg., egress; Dis., disappearance; Re., reappearance; Ec., eclipse; Oc., occultation; Tr., Transit of the Satellite; Sh., transit of the shadow.

COMET NOTES.

Elements of Comet *b* 1910.—The following preliminary elements for comet 1910 *b* have been computed from observations made with the 12-inch equatorial at Lick Observatory on August 10, 11, and 12.

$$T = \text{Sept. } 22.058$$
$$\omega = 53^\circ\ 53'\ 07''.$$
$$\Omega = 289\ \ 16\ \ 18.$$
$$i = 120^\circ\ 51'\ 32''$$
$$\log q = 0.28782$$

Constants to Equator 1910.0

$$x = r\ [9.76788] \sin [199^\circ\ 36'\ 16'' + v]$$
$$y = r\ [9.99932] \sin [294^\circ\ \ 2'\ 12'' + v]$$
$$z = r\ [9.09969] \sin [\ 26^\circ\ 20'\ 13'' + v]$$

R. Young.

Mt. Hamilton, Sept. 22,

Ephemeris of Comet *b* 1910 (Metcalf's.)

Greenwich Midnight	R.A. h	m	s	Dec. °	′	″	Log *r*	Log Δ
Nov. 5	15	36	6	+20	31	0	0.32465	0.44615
9	15	37	37	+21	0	35	0.32865	0.44801
13	15	39	17	+21	32	11	0.33271	0.44918
17	15	40	57	+22	7	41	0.33695	0.44968
21	15	42	40	+22	46	17	0.34127	0.44955
25	15	44	23	+23	28	37	0.34573	0.44883

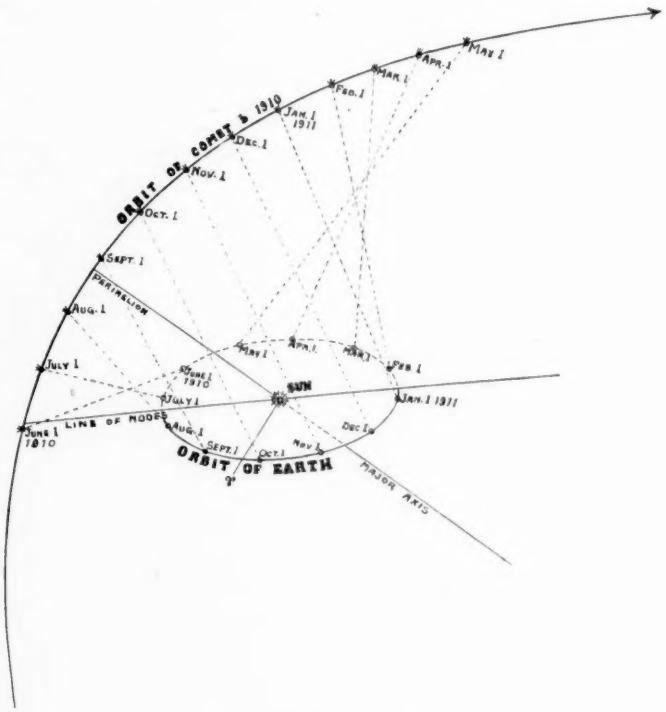
The above ephemeris of comet *b* (Metcalf's) 1910 is based upon Kobold's elements.

F. E. Seagrave.

Providence, Sept. 29, 1910.

Comet *b* 1910.—In *A. N.* 4440 Mr. H. Kobold gives the following elements of Metcalf's comet *b* 1910, derived from observations on the dates August 11, 17 and 25:

$$\begin{aligned} T &= 1910\ \text{Aug. } 26.04673 \text{ Berlin M. T.} \\ \omega &= 40^\circ\ 3'\ 24'' \\ \Omega &= 290\ 40\ 55 \quad 1910.0 \\ i &= 121\ 25\ 16 \\ \log q &= 0.282790 \end{aligned}$$



ORBIT OF COMET *b* 1910.

From these elements we have prepared the accompanying diagram, which shows the relative paths of the comet and the Earth. In the diagram the Earth's orbit is projected upon the plane of the comets orbit. It appears from this that the comet had already passed its most favorable position when it was discovered. It was nearer the Earth in June and July than in August and might have been observed to better advantage then. During the next two months it will be on the farther side of the Sun but the Earth's motion will carry us around during the winter so that in the spring we may observe it again, although owing to its increasing distance from the Sun it will be much fainter than now.

Brook's Periodic Comet 1889 V.—This comet was picked up at its third return, on the night of September 28, 1910, by Professors Wilson and Aitken with the 36-inch refractor of Lick Observatory. The comet is exceedingly faint and quite small so that it may not be detected with the aid of small telescopes. The position as measured micrometrically was

Sept. 28.7249 Gr. M. T. α 19^h 47^m 51^s.1 δ — 28° 8′ 39″

This gives as the correction to the ephemeris in *A. N.* 4439 $\Delta\alpha$ + 9^s.7 $\Delta\delta$ + 20″.

VARIABLE STARS.

New Star in Sagittarius.—A new star whose approximate position is R. A. 17^h 52^m 15^s, Dec. —27° 32′.3, (1875), was discovered by Mrs. Fleming in the Constellation Sagittarius on October 1, 1910. It appears on sixteen photographs taken at Arequipa with the 8-inch Bache and 1-inch Cooke Telescopes, between March 21, 1910 and June 10, 1910. The magnitude has been estimated as varying from 7.8 to 8.6, between these dates. The spectrum is quite faint but shows the bright hydrogen lines Hβ, Hγ, Hδ, Hϵ, Hξ, and Hη, with a trace of Hγ as dark on the edge of greater wavelength of the bright line Hγ. The star does not appear on seventeen photographs, taken between July 23, 1889 and October 7, 1909, although most of them show stars fainter than the twelfth magnitude and one plate shows stars of the fifteenth magnitude, or fainter. An observation by Leon Campbell on October 3, 1910, with the 24-inch Reflector of this Observatory confirms the presence of this object and gives its magnitude as about 10.5. Of the fifteen new stars known to have appeared during the last twenty-five years, eleven have been found at this Observatory, nine by Mrs. Fleming from the photographs of The Henry Draper Memorial.

E. C. PICKERING

Harvard College Observatory, Cambridge, Mass.
Astronomical Bulletin No. 426. Oct. 4, 1910.

Nova Arae.—A new star whose approximate position is R. A. 16^h 31^m 4^s Dec. — 52° 10′.6 (1875) was discovered by Mrs. Fleming, in the constellation Arae on October 13, 1910. It appears on 21 photographs taken at Arequipa with the 8-inch Bache and 1-inch Cooke telescopes, between April 4, 1910 and August 3, 1910. The magnitude has been estimated as varying from 6.0 to 10.0 between these dates. The spectrum is quite faint but shows, on three plates, the bright lines, 5007, Hβ, 4670, Hγ, Hδ, Hϵ and Hξ, one of the plates showing also the bright line Hη. Apparently this object had passed into a nebulous condition before its spectrum was photographed. The star does not appear on 44 photographs, taken between August 20, 1889 and March 19, 1910, although almost all of them show stars fainter than the twelfth magnitude, and two plates show stars as faint as the fifteenth magnitude.

Of the sixteen new stars found during the last twenty-five years thirteen have been found at this Observatory, one by Miss A. J. Cannon, two by Miss H. S. Leavitt from photographic charts and ten by Mrs. Fleming from the Draper Memorial photographs.

EDWARD C. PICKERING.

Harvard Astronomical Bulletin, No. 427.

The New Star in Sagittarius.—On receipt of the telegram announcing the discovery of a Nova in Sagittarius, by Mrs. Fleming of Harvard College Observatory, preparations were at once made at Lick Observatory to identify the star and photograph its spectrum. The star is in a very rich portion of the Milky Way so that its identification, so many months after it had begun to wane, might have been somewhat uncertain. A photograph, however, taken with the Willard lens with an exposure of an hour, compared with one taken by Barnard in 1892, revealed a star of about magnitude 9.5, in the place indicated by the telegram, where none appeared on the earlier photograph.

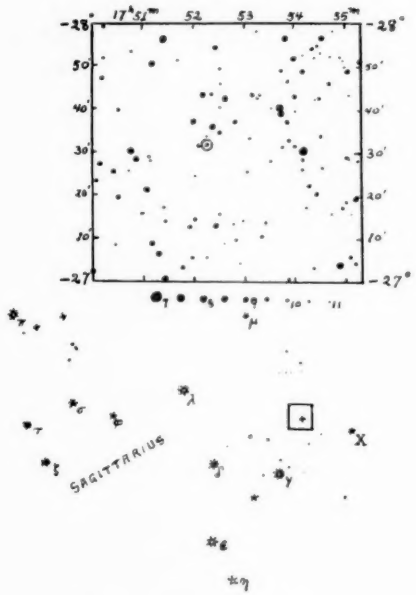


CHART OF NOVA SAGITTARII.

The accompanying diagram shows the location of the Nova, on a line one third the way from the variable star X to the third magnitude star λ in Sagittarius, marked by the cross within the small square. The upper part of the diagram shows the telescopic stars within the field of the small square. The positions and magnitudes of the stars are taken from the Cape Photographic Durchmusterung. All the stars are shown down to magnitude 10.4 and their places are for the epoch 1875. The Nova is within the small circle.

Photographs taken by Professor Wright and Mr. Burns with the Crossley reflector and slitless spectrograph show that it has the characteristic spectrum of a new star, with bright lines or bands superposed on a continuous spectrum. In all, at least nine bright bands are recorded, of which six appear to belong to the hydrogen series from Hα to Hξ inclusive. The remaining three probably correspond with Nova lines at λλ 589, 463 and 446.

Irregularities in the Motion of the Satellite of Algol.—In the *Bulletin de la Societé Astronomique de France* October, 1910, Mr. Enzo Mora, of Sequals, Italy, gives an interesting note concerning the period of variability of Algol. The ephemerides of Algol published in *l'Annuaire des Bureau des Longitudes* did not accord with the observations and a more approximate period was computed and the ephemerides, computed from this period by Mr. Mora, have been published in *l'Annuaire Astronomique Flammarion*. The following note, translated from the French, calls attention to the irregularities in this period.

"Toward the end of 1909, my attention was called to an anticipation of minima by Algol, an anticipation which seemed to increase rapidly up to February, 1910, before diminishing, no less rapidly, later. Unfortunately bad weather permitted me to make only a few observations, for the most part incomplete, hardly sufficient to give any idea of the actual perturbation necessarily produced in the system of Algol. Following are the results of observations since October, 1908:

Date	Comparison Star	Phase Observed	i	Δ	Probable Error of Δ and i
			m	m	
1908 Oct. 1, 3	ε Persei	I	97.9	+4.3	±0.9
4	"	II			
4	β Trianguli	I, II	66.8	+5.4	1.5
29	ε Persei	I, II	98.6	+4.0	1.3
1909 Aug. 26	"	II	96.2	−Δ (−0.8)	2.5
Oct. 11	"	II	98.6	−Δ (+1.6)	1.6
Nov. 3, 20	"	II, I	97	−3	3.?
1910 Jan. 0, 2	"	I	96.1	−9.5	0.8
2, 5	"	II			
Feb. 14		I	123.0	+Δ (−26)	1.5
Mar. 9	"	I	104.4	+Δ (−7.4)	1.1
Apr. 1	γ Persei	I, II	35	−2.1	1.2

"In explanation of the table it is necessary to say that I compared Algol, before and after minimum, in nearly every case, with ε Persei, for forty minutes at least, when the brightness of the two stars was quite different. From all the comparisons, each corrected for atmospheric absorption, I deduced the time of equality of brightness (e_1), (e_2), and their probable errors.

"For the observed time of minimum, I take

$$M = \frac{e_1 + e_2}{2}, \text{ or } M = e_1 + i = e_2 + i, \ i \text{ being the interval } \frac{e_2 - e_1}{2}*$$

"The general expression adopted for M is;

$$M = 1900, \text{ January } 1, 23^h\,43^m.7 \text{ (C.M.T. Paris)} + 2^d\,20^h\,48^m.9101\ E + 7^m.68\ R \sin(\odot + 35^\circ\,14') + \Delta,$$

where R and $\odot$ designate the radius vector and longitude of the Sun, referred to the equinox of 1900, at the time M; Δ is a correction varying with the time

* The use of other comparison stars furnishes analogous quantities which serve to fix more approximately the form of the light curve of Algol and to the variations. But it must be noticed that the different observations will not give identical values of *i*, if the comparison stars differ in color from the variable. Algol has about the same color as β Trianguli, ξ and ε Persei and γ Andromedæ. If we adopt for this last star the magnitude 2.2 give in *l'Annuaire du Bureau des Longitudes*, the ordinary magnitude of Algol will be 2.0 instead of 2.3.

and can be obtained only by observation. The value $\Delta = 0$ represents well my observations from 1898 to 1905; in 1906 Δ increased; it was $+5^m$ in 1907, and $+4^m$ in 1908 and decreased to 0^m in 1909, as seen in the preceding table.

"The incomplete observations of August 26, and October 11, 1909, February 14 and March 9, 1910, are not sufficient to determine Δ; if we assume, $i = 97^m$, on these charts, we find the values of Δ given in the parenthesis.

"That of February 14 is certainly too large; I cannot attribute it to the errors of observation, as the atmospheric conditions were good and the comparisons accordant; but in the observations before 1909, the values of Δ were never greater than 6 minutes.

"It is, therefore, certain that the relative motion of the companion to Algol has been subject, in a relatively short period of time, to an extraordinary disturbance, very probably greatest in the plane of the orbit. On the other hand, it is equally certain that the light-curve of Algol is subject to sensible deformations in the course of a few months. Can it be that these are secular variations?

"Since evidently, we cannot reconcile these phenomena under existing theories, and, since the simple hypothesis of Chandler and Tisserand serve to explain only a single inequality of long period in the times of minima, we are led to believe that, outside of the star Algol, there revolve other satellites whose action modifies, in a complicated manner, the elements of the orbit of the principal satellite."

New Elements of Variable Stars.—In his "*Beobachtungen Veränderlichen Sterne, Angestellt auf Dombaas, Norwegen*, Mr. Sigurd Enebo gives his observations upon fifteen variable stars discovered since 1907. The following is a summary of his results:

1. S T Persei. Algol Type. Min. $= 2418678^d.272 + 2.^d648382$ E. Range $9^m.4-11^m.8$. Duration of Min. 9^h.
2. R V Persei. Algol Type. Min. $= 2417972^d.314 + 1^d.973517$ E. Range $10^m.7-12^m.8$. Duration of Min. 7^h.
3. R V Tauri. β Lyræ Type. Principal Min. $= 2417608^d.5 + 79.^d0$ (Scares).
4. R W Aurigae. Irregular.
5. S X Aurigae. Min. $= 2417853^d.34 + 1.53172$ E. Max. Period Variable. Range $8^m.3-8^m.8$.
6. S V Tauri. β Lyrae Type? Principal Min. $2418683^d.35 + 2^d.16689$ E. Range 9.3—10.1.
7. R R Aurigae. Max $= 2417153^d + 311^d$ E. Range 9.0—$<12^m.5$.
8. S S Aurigae U Geminorum Type.
9. X Cancri. Irregular. Range $6^m.0-7^m.3$.
10. R X Ursae Maj. Max. $= 2417847^d + 64^d$ E. Range $10^m.7-11^m.9$.
11. A B Cygni. Max. $= 2418320^d + 482^d$ E. Range $8^m.1-8^m.9$.
12. R T Lacertae Algol type. Principal Min. ($10^m.2$) $= 2418326^d.24 + 5^d.07257$ E. Second Min. $= 2418328^d.82 + 5^d.07257$ E. Normal light $9^m.0$.
13. R S Lacertae. Max. $= 2418340^d + 230^d$ E. Range $9^m.3-12.0$. M-m $= 115^d$.
14. S T Pegasi. Elements unknown. Range $8^m.3-9^m.4$.
15. T V Andromedae. Irregular. Range $8^m.9-11^m.1$.

Approximate Magnitudes of Variable Stars on Oct. 1, 1910.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900. h	m	Decl. 1900. °	′	Magn.	Name.	R.A. 1900. h	m	Decl. 1900. °	′	Magn
χ Androm.	0	10.8	+46	27	12.5*d*	R Lyncis	6	53.0	+55	28	12.0 *i*
T Androm.		17.2	+26	26	12.5*d*	RS Gemin.		55.2	+30	40	10.4
T Cassiop.		17.8	+55	14	11.7*d*	R Gemin.	7	1.3	+22	52	7.3
R Androm.		18.8	+38	1	10.5 *i*	V Can. Min.		1.5	+ 9	2	9.2 *i*
S Ceti		19.0	− 9	53	8.3	R Can. Min.		3.2	+10	11	9.3
U Cassiop.		40.8	+47	43	13.0*d*	RR Monoc.		12.4	+ 1	17	10.2
RW Androm.		41.9	+32	8	10.0 *i*	V Gemin.		17.6	+13	17	13.2
V Androm.		44.6	+35	6	<13	S Can. Min.		27.3	+ 8	32	11.3
RR Androm.		45.9	+33	50	<13	S Gemin.		37.0	+23	41	9.6
Z Ceti	1	1.6	− 2	1	9.5	T Gemin.		43.3	+23	59	12.8
S Piscium		12.4	+ 8	24	<13.5	U Gemin.		49.2	+22	16	10.5 *i*
S Cassiop.		12.3	+72	5	13.0*d*	R Urs. Maj.	10	37.6	+69	18	13.0
U Piscium		17.7	+12	21	11.6 *i*	T Urs. Maj.	12	31.8	+60	2	8.5 *i*
R Piscium		25.5	+ 2	22	<13.2	RS Urs. Maj.		34.4	+59	2	12.0 *i*
RU Androm.		32.8	+38	10	11.5*d*	S Urs. Maj.		39.6	+61	38	10.5*d*
Y Androm.		33.7	+38	50	<13	R Can. Ven.	13	44.6	+40	2	8.3
X Cassiop.		49.8	+58	46	10.0	U Urs. Min.	14	15.1	+67	15	9.6*d*
S Arietis		59.3	+12	3	11.3	S Bootis		19.5	+54	16	12.0*d*
R Arietis	2	10.4	+24	35	11.1*d*	V Bootis		25.7	+39	18	7.5 *i*
W Androm.		11.2	+43	50	7.8 *i*	R Camelop.		25.1	+84	17	12.2*d*
o Ceti		14.3	− 3	26	4.3*d*	R Bootis		32.8	+27	10	11.6*d*
R Ceti		20.9	− 0	38	12.6*d*	S Serpentis	15	17.0	+14	40	8.5
RR Persei		21.7	+50	49	<13	S Coronae		17.3	+31	44	12.8*d*
U Ceti		28.9	−13	35	8.3	S Urs. Min.		33.4	+78	58	10.8*d*
R Trianguli		31.0	+33	50	11.1*d*	R Coronae		44.4	+28	28	7.4*d*
T Arietis		42.8	+17	6	9.3	X Coronae		45.2	+36	35	10.5*d*
U Arietis	3	5.5	+14	25	13.3	R Serpentis		46.1	+15	26	10.4*d*
X Ceti		14.3	− 1	26	9.6*d*	V Coronae		46.0	+39	52	11.8*d*
Y Persei		20.9	+43	50	9.3	Z Coronae		52.0	+29		8.4 *i*
R Persei		23.7	+35	20	10.2*d*	R Herculis	16	1.7	+18	38	11.8 *i*
Nov. Per. No. 2		24.4	+43	34	12.5	RU Herculis		6.0	+25	20	<14
T Tauri	4	16.2	+19	18	11.6	U Herculis		21.4	+19	7	9.6 *i*
R Tauri		22.8	+ 9	56	<13	W Herculis		31.7	+37	32	12.1 *i*
W Tauri		22.2	+15	49	12.3	R Draconis		32.4	+66	58	10.5 *i*
S Tauri		23.7	+ 9	44	<13	S Herculis		47.4	+15	7	10.6*d*
T Camelop.		30.4	+65	57	12.7*d*	RV Herculis		56.8	+31	22	14.4*d*
RX Tauri		32.8	+ 8	9	<13	R Ophiuchi	17	2.0	−15	58	10.1*d*
X Camelop.		32.6	+74	56	8.5 *i*	RT Herculis		6.8	+27	11	9.3 *i*
V Tauri		46.2	+17	22	11.9 *i*	T Draconis		54.8	+58	14	11.8 *i*
R Orionis		53.6	+ 7	59	12.5	— Draconis		54.7	+58	13	11.0*d*
V Orionis	5	0.8	+ 3	58	11.3 *i*	RY Herculis		55.4	+19	29	<11.8
R Aurigae		9.2	+53	28	11.1*d*	V Draconis		55.6	+54	53	13.6*d*
S Aurigae		20.5	+34	4	9.4*d*	T Herculis	18	5.3	+31	0	9.3*d*
W Aurigae		20.1	+36	49	<13	W Draconis		5.4	+65	56	14.2
S Orionis		24.1	− 4	46	12.2	X Draconis		6.8	+66	8	11.5
T Orionis		30.9	− 5	32	9.8	W Lyrae		11.5	+36	38	7.8 *i*
S Camelop.		30.2	+68	45	11.4	SV Herculis		22.3	+24	58	<12
RR Tauri		33.3	+26	19	11.5	X Ophiuchi		33.6	+ 8	44	8.8
U Aurigae		35.6	+31	59	10.4 *i*	RY Lyrae		41.2	+34	34	10.0
SU Tauri		43.2	+19	2	10.7 *i*	RW Lyrae		42.1	+43	32	<14.5
Z Tauri		46.7	+15	46	<13.2	RX Lyrae		50.4	+32	42	12.0 *i*
U Orionis		49.9	+20	10	8.1*d*	ST Sagittarii		55.9	−12	54	<13
Z Aurigae		53.6	+53	18	9.6	Z Lyrae		56.0	+34	49	13.3
X Aurigae	6	4.4	+50	15	11.1	RT Lyrae		57.8	+37	22	11.0
R Monoc.		33.7	+ 8	49	11.7	R Aquilae	19	1.6	+ 8	5	11.3*d*
X Gemin.		40.7	+30	23	8.0	V Lyrae		5.2	+29	30	<14.5
Y Monoc.		51.3	+11	22	11.2 *i*	RX Sagittarii		8.7	−18	59	13.3

Approximate Magnitudes of Variable Stars on Oct. 1, 1910—Con.

Name.	R. A. 1900. h m	Decl. 1900. ° ′	Magn.	Name.	R. A 1900 h m	Decl. 1900 ° ′	Magn
RW Sagittarii	19 8.1	−19 2	9.1	V Capricorni	21 1.8	−24 19	12.3
S Lyrae	9.1	+25 50	14.0*d*	X Capricorni	2.8	−21 45	12.0
RS Lyrae	9.3	+33 15	13.8*d*	X Cephei	3.6	+82 40	<14
RU Lyrae	9.1	+41 8	10.8*d*	RS Aquarii	5.8	− 4 27	10.2
U Draconis	9.9	+67 7	11.8*d*	Z Capricorni	5 0	−16 35	9.8
T Sagittarii	10.5	−17 9	8 9*d*	T Cephei	8.2	+68 5	6.5 *i*
R Sagittarii	10.8	−19 29	7.3 *i*	RR Aquarii	9.8	− 3 19	9.3 *i*
RY Sagittarii	10.0	−33 42	7.2*d*	R Equulei	8.4	+12 23	10.2 *i*
S Sagittarii	13.6	−19 12	<13	X Pegasi	16.3	+14 2	9.2 *i*
Z Sagittarii	13.8	−21 7	<13	T Capricorni	16.5	−15 35	<13
TZ Cygni	13.4	+50 0	11.0	Y Capricorni	28.9	−14 25	13.0
U Lyrae	16.6	+37 42	11.3*a*	S Cephei	36.5	+78 10	8.0
T Sagittae	17.2	+17 28	9.5 *i*	RR Pegasi	40.0	+24 33	9.5
TY Cygni	29.8	+28 6	11.5	V Pegasi	56.0	+ 5 38	<13.5
RT Aquilae	33.3	+11 30	13.2*d*	U Aquarii	57.9	−17 6	11.2
R Cygni	34.1	+49 58	8.2 *i*	RT Pegasi	59.8	+34 38	11.7*d*
RT Cygni	40.8	+48 32	9.4*d*	T Pegasi	22 4.0	+12 3	12.2 *i*
TU Cygni	43.3	+48 49	12.2*d*	Y Pegasi	6.8	+13 52	<13
X Aquilae	46.5	+ 4 13	8.7 *i*	RS Pegasi	7.4	+14 4	12.8
χ Cygni	46.7	+32 40	9.3*d*	X Aquarii	13.2	−21 24	12 7
RR Aquilae	52.4	− 2 11	10.2*d*	RT Aquarii	17.7	−22 34	9.6
RS Aquilae	53.7	− 8 9	<13	S Lacertae	24.6	+39 48	12.9
Z Cygni	58.6	+49 46	13.0	R Lacertae	38.8	+41 51	12.9
SY Aquilae	20 2.3	12 39	<13	S Aquarii	51.8	−20 53	10 7
S Cygni	3.4	+57 42	10.5 *i*	RW Pegasi	59.2	+14 46	<12
R Capricorni	5.7	−14 34	12.0 *i*	R Pegasi	23 1.6	+10 0	7.6 *i*
S Aquilae	7.0	+15 19	9.8	V Cassiop.	7.4	+59 8	9.0 *i*
RU Aquilae	8.0	+12 42	<12.5	W Pegasi	14.8	+25 44	9.2 *i*
Z Aquilae	9.8	− 6 27	10.2*d*	S Pegasi	15.5	+ 8 22	11.8
R Delphini	10.1	+ 8 47	8.8 *i*	Z Androm.	28 8	+48 16	10.7
SX Cygni	11.6	+30 46	<12	ST Androm.	33.8	+35 13	10.0
U Cygni	16.5	+47 35	8.2	Z Cassiop.	39.7	+56 2	<13.3
RW Cygni	25.2	+39 39	8.3	R Aquarii	38.6	−15 50	9.3
Z Delphini	28.1	+17 7	11.3*d*	Z Aquarii	47.1	−16 25	7.4
S Delphini	38.5	+16 44	10.0	V Ceti	52.8	− 9 31	<13 6
V Cygni	38.1	+47 47	<13	RR Cassiop.	50.7	+53 8	11.3 *i*
T Delphini	40.7	−16 2	<13	R Cassiop.	53.3	+50 50	11.8*d*
V Delphini	43.2	+18 58	<14	Z Pegasi	55.0	+25 21	9.1 *i*
T Aquarii	44.7	− 5 31	7.5 *i*	W Ceti	57.0	−15 14	7.5
R Vulpeculae	59.9	+23 26	9.3*d*	Y Cassiop.	58.2	+55 7	11.0*d*

The letter *i* denotes that the light is increasing; the letter *d*, that the light is decreasing; the sign <, that the variable is fainter than the appended magnitude. The above magnitudes have been compiled by Mr. Leon Campbell of the Harvard College Observatory from observations made at the Harvard, Amherst, Mt. Holyoke, Olcott, and Jacobs, Observatories.

Minima of Variable Stars of the Algol Type.

[Given to the nearest hour in Greenwich Mean Time beginning with noon. To reduce to Central Standard time subtract 6 hours, or for Eastern time subtract 5 hours, etc. For stars marked with an * alternate minima are given; ** every third minimum; † every tenth minimum.]

SY Androm.		U Cephei		*Z Persei		RY Persei		**RZ Cassiop.	
d	h	d	h	d	h	d	h	d	h
Dec. 11	6	Dec. 15	0	Dec. 2	2	Dec. 6	23	Dec. 2	11
*U Cephei		20	0	8	5	13	20	6	1
Dec. 5	1	25	0	14	7	20	17	9	15
10	1	29	23	20	10	27	13	13	5
				26	13			16	19

Minima of Variable Stars of the Algol Type.—Continued.

**** RZ Cassiop**

d	h
Dec. 20	9
24	0
27	14
31	4

***ST Persei**

d	h
Dec. 5	22
11	5
16	12
21	19
27	2

RX Cephei

d	h
Dec. 23	0

***Algol**

d	h
Dec. 1	4
6	21
12	15
18	9
24	2
29	20

****RT Persei**

d	h
Dec. 2	9
4	22
7	11
10	0
12	14
15	3
17	16
20	5
22	18
25	7
27	21
30	10

λ Tauri

d	h
2	12
6	11
10	10
14	8
18	7
22	6
26	5
30	4

***RW Tauri**

d	h
Dec. 3	6
8	19
14	8
19	21
25	10
30	23

***RV Persei**

d	h
Dec. 2	11
6	10
10	8
14	7
18	6
22	5
26	3
30	2

RW Persei

d	h
Dec. 8	24
22	5

RS Cephei

d	h
Dec. 9	22
22	8

***RY Aurigae**

d	h
Dec. 2	11
7	22
13	9
18	20
24	7
29	17

*** RZ Aurigæ**

d	h
Dec. 5	14
11	15
17	15
23	16
29	17

***RW Gemin.**

d	h
Dec. 4	11
7	8
13	1
18	19
24	12
30	6

***U Columbæ**

d	h
Dec. 5	0
10	15
16	5
21	19
27	10

***RW Monoc.**

d	h
Dec. 1	7
5	2
8	22
12	17
16	13
20	8
24	4
27	23
31	19

RX Gemin.

d	h
Dec. 1	20
14	1
26	6

****RU Monoc.**

d	h
Dec. 1	4
3	20
6	13
9	5
11	22
14	14
17	7
19	24
22	16
25	9
28	1
30	18

****R Canis Maj.**

d	h
Dec. 3	0
6	10
9	20
13	6
16	16
20	1
23	11
26	21
30	7

RY Geminorum

d	h
Dec. 4	11
13	19
23	2

***Y Camelop.**

d	h
Dec. 4	7
10	22
17	12
24	3
30	18

RR Puppis

d	h
Dec. 2	13
8	23
15	10
21	20
28	6

****V Puppis**

d	h
Dec. 1	22
6	7
10	16
15	0
19	9
23	18
28	3

†X Carinæ

d	h
Dec. 3	13
6	19
10	1
13	7
16	13
19	19
23	1
26	7
29	13

S Canem

d	h
Dec. 5	20
15	8
24	19

S Velorum

d	h
Dec. 2	12
8	11
14	9
20	8
26	6

****Y Leonis**

d	h
Dec. 1	4
6	5
11	6
16	8
21	9
26	11
31	14

****RR Velorum**

d	h
Dec. 2	9
7	23
13	12
19	2
24	15
28	8

***SS Carinae**

d	h
Dec. 3	3
9	18
16	8
22	23
29	13

RW Urs. Maj.

d	h
Dec. 3	11
10	19
18	3
25	11

****Z Draconis**

d	h
Dec. 1	15
5	16
9	18
13	20
17	22
21	23
26	1
30	3

***SS Centauri**

d	h
Dec. 1	24
6	23
11	22
16	21
21	19
26	18
32	17

***δ Libræ**

d	h
Dec. 1	14
6	5
10	21
15	13
20	4
24	20
29	12

***U Coronæ**

d	h
Dec. 3	5
10	2
17	0
23	22
30	20

***SW Ophiuchi**

d	h
Dec. 1	16
6	14
11	11
16	9
21	6
26	3
31	1

***SX Ophiuchi**

d	h
Dec. 2	0
6	3
10	6
14	9
18	12
22	15
26	18
30	21

R Aræ

d	h
Dec. 1	22
6	8
10	18
15	4
19	14
24	1
28	11

****U Ophiuchi**

d	h
Dec. 1	3
3	15
6	4
8	16
11	4
13	17
16	5
18	18
21	6
23	18
26	7
28	19
31	8

****SZ Herculis**

d	h
Dec. 3	0
5	11
7	21
10	8
12	19
15	6
17	17
20	4
22	15
25	2
27	13
30	0

Z Herculis

d	h
Dec. 1	15
5	14
9	14
13	14
17	14
21	14
25	14
29	13

***RS Sagittarii**

d	h
Dec. 5	10
10	6
15	1
19	21
24	17
29	13

Minima of Variable Stars of the Algol Type.—Continued.

*V Serpentis

	d	h
Dec.	6	19
	13	17
	20	15
	27	13

‡RZ Draconis

	d	h
Dec.	1	11
	5	21
	11	9
	16	22
	22	10
	27	22

**RX Herculis

	d	h
Dec.	2	13
	5	5
	7	21
	10	13
	13	5
	15	21
	18	13
	21	5
	23	21
	26	13
	29	5
	31	21

*SX Sagittarii

	d	h
Dec.	3	16
	7	20
	11	23
	16	2
	20	7
	24	11
	28	14

*RR Draconis

	d	h
Dec.	2	11
	8	2
	13	18
	19	10
	25	2
	30	18

**U Scuti

	d	h
Dec.	3	8
	6	4
	9	1
	11	22
	14	19
	17	15
	20	12
	23	9
	26	6
	29	2
	31	23

*RX Draconis

	d	h
Dec.	4	1
	7	20
	11	14
	15	9
	19	4
	22	23
	26	18
	30	13

*RV Lyræ

	d	h
Dec.	2	21
	10	2
	17	6
	24	11
	31	16

*U Sagittae

	d	h
Dec..	4	1
	10	19
	17	13
	24	7
	31	2

Z Vulpeculæ

	d	h
Dec.	1	10
	6	11
	11	13
	16	14
	21	15
	26	16
	31	17

SY Cygni

	d	h
Dec.	5	8
	11	8
	17	8
	23	8
	29	8

*WW Cygni

	d	h
Dec.	2	10
	9	2
	15	17
	22	8
	28	23

SW Cygni

	d	h
Dec.	1	20
	6	10
	10	24
	15	14
	20	3
	24	17
	29	7

VW Cygni

	d	h
Dec.	6	16
	15	2
	23	13
	31	23

*UW Cygni

	d	h
Dec.	7	18
	14	16
	21	14
	28	11

W Delphini

	d	h
Dec.	4	5
	9	0
	13	20
	18	15
	23	10
	28	6

RR Delphini

	d	h
Dec.	5	7
	9	20
	14	11
	19	2
	23	16
	28	6

RR Vulpeculae

	d	h
Dec.	3	12
	8	13
	13	15
	18	16
	23	17
	28	18

**VV Cygni

	d	h
Dec.	1	14
	6	0
	10	11
	14	21
	19	7
	23	18
	28	4

UZ Cygni

	d	h
Dec.	24	14

*RT Lacertae

	d	h
Dec.	2	13
	7	15
	12	17
	17	19
	22	20
	27	22

*TT Androm.

	d	h
Dec.	6	12
	12	1
	17	13
	23	2
	28	15

21.1909 Andr.

	d	h
Dec.	1	18
	5	21
	9	24
	14	3
	18	5
	22	8
	26	11
	30	14

Maxima of Variable Stars of Short Period not of the Algol Type.

Unless otherwise indicated the times of maxima only are given; and the times of minima may be found by subtracting the interval printed in parentheses under the names of the stars.

SX Cassiop.

	d	h
Dec.	2	19

SY Cassiop.

	d	h
Dec.	4	16
	8	18
	12	20
	16	21
	20	23
	25	1
	29	2

RW Cassiop.

	d	h
	(−5	19)
Dec.	10	2
	24	22

SU Cassiop.

	d	h
	(−0	22)
Dec.	2	6
	4	5
	6	4
	8	3
	10	2
	12	0
	13	23
	15	22
	17	21
	19	19
	21	18
	23	17
	25	16
	27	14
	29	13
	31	12

SV Persei

	d	h
Dec.	5	4
	16	7
	27	20

RX Aurigæ

	d	h
	(−4	0)
Dec.	7	3
	18	18
	30	9

SX Aurigae

	d	h
Dec.	2	5
	3	18
	5	6
	6	19
	8	8
	9	21
	11	9
	12	22

SX Aurigae

	d	h
Dec.	14	11
	15	24
	17	12
	19	1
	20	14
	22	3
	23	16
	25	4
	26	17
	28	6
	29	19
	31	7

SY Aurigae

	d	h
Dec.	3	7
	13	10
	23	14

Y Aurigae

	d	h
	(−0	18)
Dec.	1	22
	5	18
	9	15
	13	12
	17	8
	21	5
	25	2
	28	22

RZ Geminorum

	d	h
	(−1	7)
Dec.	1	21
	7	10
	12	22
	18	10
	23	23
	29	11

Maxima of Variable Stars of Short Period not of the Algol Type.-Con.

RS Orionis

	d	h
	(−2	0)
Dec.	8	5
	15	18
	23	8
	30	21

T Monoc.

	(−9	23)
Dec.	27	21

W Geminorum

	(−2	2)
Dec.	7	9
	15	8
	23	5
	31	3

ζ Geminorum

	(−5	0)
Dec.	1	8
	11	12
	21	16
	31	19

RU Camelop.

	(−9	12)
Dec.	17	0

V Carinæ

	(−2	4)
Dec.	4	9
	11	1
	17	18
	24	11
	31	3

T Velorum

	(−1	10)
Dec.	1	20
	6	12
	11	3
	15	19
	20	10
	25	1
	29	17

W Carinæ

	(−1	0)
Dec.	1	22
	6	7
	10	15
	15	0
	19	9
	23	18
	28	3

S Muscæ

	(−3	11)
Dec.	1	21
	11	13
	21	4
	30	20

T Crucis

	(−2	2)
Dec.	1	1
	7	19
	14	12
	21	6
	27	23

R Crucis

	d	h
	(−1	10)
Dec.	5	14
	11	10
	17	6
	23	2
	28	21

S Crucis

	(−1	12)
	2	15
	7	8
	12	0
	16	17
	21	10
	26	2
	30	19

RZ Centauri

Dec.	1	9
	2	8
	3	6
	4	5
	5	3
	6	2
	7	0
	7	23
	8	21
	9	20
	10	18
	11	17
	12	15
	13	14
	14	12
	15	11
	16	9
	17	8
	18	6
	19	5
	20	3
	21	2
	22	0
	22	23
	23	21
	24	20
	25	18
	26	17
	27	15
	28	14
	29	12
	30	11
	31	9

W Virginis

	(−8	5)
Dec.	6	5
	23	11

V Centauri

	(−1	11)
Dec.	2	15
	8	3
	13	15
	19	3
	24	14

R Triang. Austr.

	d	h
	(−1	0)
Dec.	1	13
	4	23
	8	8
	11	17
	15	3
	18	12
	21	22
	25	7
	28	16

S Triang. Austr.

	(−2	2)
Dec.	7	7
	13	15
	19	22
	26	6

S Normæ

	(−4	10)
Dec.	2	11
	12	5
	21	23
	31	17

RV Scorpii

	(−1	10)
Dec.	2	22
	8	23
	15	1
	21	2
	27	4

RV Ophiuchi Minimum

Dec.	2	19
	6	12
	10	4
	13	21
	17	13
	21	6
	24	22
	28	15

X Sagittarii

	(−2	22)
Dec.	3	16
	10	16
	17	16
	24	17
	31	17

Y Ophiuchi

	(−6	5)
Dec.	10	1
	29	4

W Sagittarii

	(−3	0)
Dec.	4	18
	12	8
	19	23
	27	13

Y Sagittarii

	d	h
	(−2	2)
Dec.	2	10
	8	4
	13	23
	19	19
	25	12
	30	6

U Sagittarii

	(−2	23)
Dec.	2	22
	9	16
	16	10
	23	4
	29	22

β Lyræ

	(−3	7)
	(−3	2)
	4	18
	11	9
	17	15
	24	7
	30	13

κ Pavonis

	(−4	7)
Dec.	5	13
	14	15
	23	17

U Aquilæ

	(−2	4)
Dec.	7	9
	14	9
	21	10
	28	11

U Vulpeculæ

	(−2	3)
Dec.	5	6
	13	5
	21	5
	29	4

SU Cygni

	(−1	7)
Dec.	3	20
	7	16
	11	13
	15	9
	19	5
	23	2
	26	22
	30	18

η Aquilae

	(−2	6)
Dec.	5	1
	12	5
	19	10
	26	4

S Sagittae

	d	h
	(−3	10)
Dec.	3	18
	12	3
	20	12
	28	21

X Vulpeculae

	(−2	1)
Dec.	6	6
	12	14
	18	21
	25	5
	31	13

V Vulpeculae Minimum

Dec.	12	22

X Cygni

	(−6	19)
Dec.	15	16

T Vulpeculae

	(−1	10)
Dec.	2	21
	7	8
	11	18
	16	5
	20	15
	25	2
	29	12

TX Cygni

Dec.	10	5
	24	23

VY Cygni

	(−2	14)
Dec.	5	16
	13	12
	21	9
	29	6

VZ Cygni

	(−1	1)
Dec.	1	8
	6	5
	11	2
	15	22
	20	19
	25	16
	30	13

Y Lacertae

	(−1	10)
Dec.	2	13
	6	21
	11	5
	15	12
	19	20
	24	4
	28	12

Maxima of Variable Stars of Short Period not of the Algol Type—Con

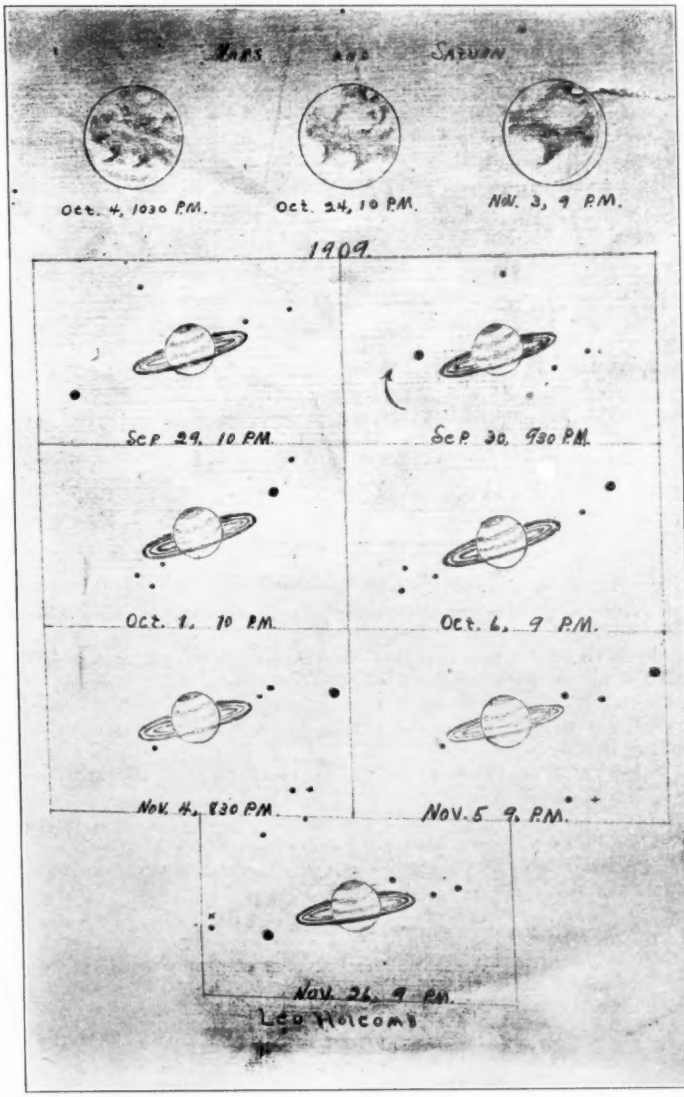
δ Cephei		Z Lacertae		V Lacertae		X Lacertae		RS Cassiop.	
d	h	d	h	d	h	d	h	d	h
				(−1	16)			(−1	19)
Dec. 4	21	Dec. 2	13	Dec. 2	15	Dec. 12	6	Dec. 1	11
10	6	13	11	7	15	17	17	7	18
15	15	24	8	12	14	23	3	14	2
20	23	RR Lacertae		17	14	28	14	20	9
26	8	(−1	2)	22	13	SW Cassiop.		26	16
31	17	Dec. 5	6	27	13	Dec. 3	21		
		11	16	X Lacertae		9	8	RY Cassiop.	
		18	2	Dec. 1	9	14	18	(−7	10)
		24	12	6	19	20	5	Dec. 12	1
						25	15	24	5
						31	2		

COMMUNICATIONS QUESTIONS AND ANSWERS.

[This department is designed especially for the use of amateurs. Beginners are invited to send in their puzzling questions. The editors will try to see that answers are given to reasonable questions but will not hold themselves responsible for the correctness of the views expressed in the communications which may find place here. All communications should be brief.]

Pencil Sketches of Mars and Saturn.—In offering these rough pencil sketches of Mars and Saturn for publication in these columns, I am taking for granted that "POPULAR ASTRONOMY" is largely read by amateurs like myself, who are fortunate enough to possess a telescope of moderate power, and who have, therefore, been viewing the heavenly bodies from time to time. I hope then, that to such as these, the sketches may be of some interest. I make no effort as it will be readily seen, to reproduce Mars or Saturn as they really appear, but in the case of Mars, I try to present the general configuration of the dark patches as I saw them on these dates. As to Saturn, it is with his moons that I am concerned. I am not expert enough to identify all of them positively and it is much for this reason that I offer these sketches with the hope that some other observers will verify, or compare their observations with mine on these dates. It will be noticed that I have placed a cross near one point of light in three of the sketches, Nov. 4, 5 and 26. I felt some doubt about this object being a Moon. In the sketch dated Nov. 26, there are six points of light in the field. The western most I believed might be a star. The one farthest north appeared quite distant for a Moon, but otherwise had every appearance of one. If it should prove that they are all moons, then I saw six on this date, the most that I have ever seen certainly. This was the last date on which I have had a good view of Saturn, and for that reason, could not further confirm my observations.

I have said in a letter appearing in a previous number of this paper that I made my own telescope, and it is my great hope that many others who may have read the article, and are not so fortunate as to possess a telescope will be induced to begin making one at once. I never viewed a single celestial object through a telescope in my life until I viewed them with the telescope made with my own hands, completed only last spring. I have two 10¼″ mirrors, one of which I intend to use unsilvered for observing the Sun, and the other for stars, planets and Moon.



Pencil Sketches of Mars and Saturn by Leo Holcomb.

The sketch of Mars dated October 4, is drawn as I saw it with my 10¼"-80" focus, the silver film of which was badly tarnished and full of holes, but the seeing and definition particularly good. The linear markings appearing at the ends of the two blunted projections and running nearly at right angles, appeared more like canals than anything that I have seen on Mars before or since. The Mars sketched dated October 24, is a view had with the mirror which I intend using for the Sun, and was the first test I gave it before silvering, after having figured and corrected it. I have left this mirror out all winter, and have used it when the weather was favorable as I have found it to do good work on double stars, as well as upon the planets and Moon.

The third sketch of Mars dated Nov. 3, is an attempt to reproduce a view I had of it with an 8½" Brashear mirror of 72" focus of good figure and bearing an excellent silver film. On this date Mars was getting so far past opposition that it appeared quite gibbous, and was fast growing smaller in size.

I will be more than pleased if any fellow observers will be interested enough to make any comments on my sketches, with the evidence in view, which I have offered from brief experience, for it will be understood that these are my initial productions, and I mean to take the position of one who is expecting to learn.

LEO HOLCOMB.

Decatur, Ill. Feb. 15, 1910.

Transit of Jupiter's Fourth Satellite.—In the tables of Phenomena of Jupiter's Satellites published in POPULAR ASTRONOMY, I notice that no mention is made of transits or occultations of Satellite IV during the present year. From this I conclude that the satellite according to calculation, should pass so far to the north or south of Jupiter's equator as to entirely escape the planet's disc. On the evening of July 11, however, I watched the satellite approach and completely disappear within Jupiter's limb. Following is an account of the phenomenon:

8.15 P. M. E. S. T. The satellite close to Jupiter, and considerably to the north of the planet's equator.

8:40 The satellites apparently touching Jupiter's disc, at a point about ten or fifteen degrees around from the north pole.

8:55 The satellite, or the edge of it, visible as a tiny fleck on Jupiter's limb close to the north pole.

9:05 No trace of the Satellite. Jupiter's limb smooth.

9:10 The same.

I was not able to observe after this, nor to ascertain how long the transit lasted. In making these observations I used a power of 125 on a five-inch telescope made by Alvan Clark and Sons.

GEORGE F. NOLTE.

Weston, Mass. July 14, 1910.

Editor's Note. It is true that the American Ephemeris records no prediction of phenomena for Satellite IV after January 1910. The diagram is marked, "no eclipse" indicating that the Satellite passes south of the planet. It may be possible for this to be true and the satellite still pass close enough in front of the planet to be projected upon its disc. (Ed.)

Observations of Halley's Comet.*—Halley's comet, which was rediscovered by Dr. Max Wolf at Heidelberg Germany, on the night of September 11, 1909, was first observed by me on the night of the 29th of December, 1909, with the aid of my 3-inch alt-azimuth refractor.

In the search for Halley's celestial visitor on December 29, 1909, the stars 31 Arietis, 38 Arietis and 85 Ceti were sought in the finder of the 3-inch refractor, and every star was identified, that was observed According to an ephemeris, the comet was to be found not far from the star 31 Arietis. After the correct position of Halley's comet was obtained in the finder, (which has a clear aperture of 1⅛ inches,) the field was carefully scrutinized in the telescope and a faint star-like object was seen which was undoubtedly the comet, for it was in exactly the correct position. With the exception of a very slight haze about it, the object resembled the neighboring faint stars, but could still be distinguished from them. The stellar point was probably a nucleus and the slight haze, possibly a small tail.

Conditions, principally atmospheric, prevented further observation of the comet till February 10, 1910. It was not difficult to locate on this date, as it was almost exactly between the stars ϵ and δ Piscium. Its position was quickly perceived in the finder and it was found in the telescopic field. I may describe the comet as appearing as a simple, faint, oval mass, rather large in angular dimensions, with a condensation to what was apparently a nucleus at one end.

My next observation of the Halley comet was made on February 19th, when its light was visible in the finder. It appeared practically the same as it had on the 10th, having undergone no radical changes. I again observed it on February 27. I found that as time went on, the comet became more oval in form, its light whiter, and the nuclear condensation more apparent.

My next observation of Halley's comet, after February 27, was made on the morning of May 4, 1910, when it was an attractive object to the naked eye. The telescopic appearance was very striking; the nucleus, which was engulfed in a large coma, appeared as a bright, yellow disc, and the tail which apparently issued from the nucleus was seen double for a considerable distance. The coma was very complex in appearance; it had some beautiful yellow jets in it, as well as other details. I estimated the magnitude of the nucleus to be 2, from observing Polaris; also I estimated the length of the tail to be from 15 to 20 degrees. The apparition of the comet was made still more impressive by the presence of the Moon and Venus in the same part of the sky. The following morning, May 5, I again observed the comet. It was a very wonderful object to the unaided eye because the tail was very large and long. In the telescope it was remarkable; the nucleus was engulfed in a large coma and the division in the tail was very apparent. The entire head of the comet was very large. I may add that on the last two observations mentioned, the great celestial wanderer was a *typical comet*.

FREDERIC C. LEONARD.

Leonard Observatory,
Madison Pk., Chicago.

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* *Delivered before the Press Club of Chicago, May 17, 1910.*

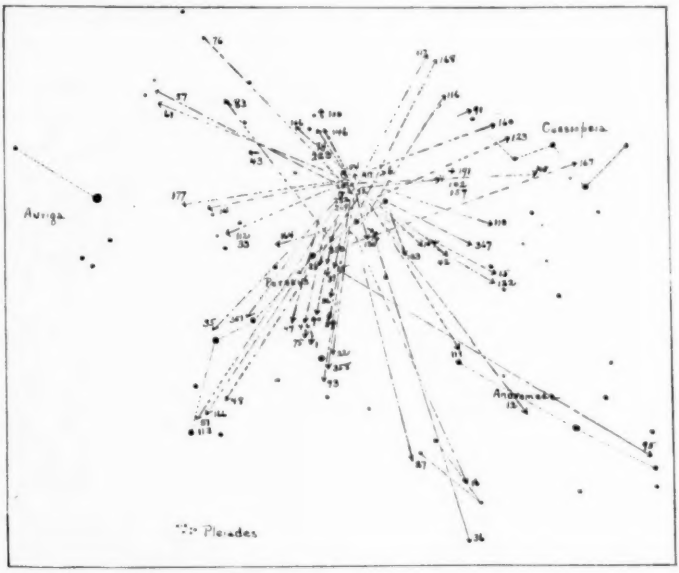
Halley's Comet.—I send herewith a copy of my notes of observations of Halley's comet of May 27th. I have no knowledge of any phenomena of this kind ever having been observed and recorded, and am desirous of knowing whether the professional astronomers have observed similar phenomena at either the present or last apparition of Halley's comet.

"May 27. 8 to 9:30. Beautiful object. Preceded a star of the 7th magnitude by 8′. Several telescopic stars observed in the dense part of the tail within 10′ of the nncleus. Nucleus well defined and as bright as a star of the 7th magnitude. A flash from the nucleus clearly seen. It was confined to a point of light which darted seemingly Earthward. After an interval of several minutes a moderately bright flare-up occurred, and while it lasted the dense part of the coma around the nucleus presented a mottled aspect. The flare-up gradually subsided in two and a half seconds of time. Atmospheric conditions for seeing at their best. The tail traced for a distance of 15° by ua-assisted eye".

DAVID GOODBREAD.

Philadelphia, Aug. 9, 1910.

The Perseids, 1910.—August 10 was partly cloudy, but no Perseids were seen. August 11, after a heavy thunderstorm with spectacular lightning it cleared off nicely at about 11 o'clock. From 11 on, with the exception of banks of fog which arose from the river, the sky was beautifully clear.



PERSEIDS OF 1910.

August 12 was clear as a crystal all night long. On August 11, 295 Perseids and 44 β Andromedids, Cygnids and one or two ordinary shooting stars were observed. August 12, 185 Perseids and 59 β Andromedids and others were observed.

	Perseids	Others	Time
July 29	3		
Aug. 5	2		
" 10	0	Part Cloudy	
" 11	295	54	11.30—3.32
" 12	185	59	11.00—3.13

Aug. 11	Time	Perseids	Others	Notes
	11.30—12.00	32	7	
	12.00—12.30	28	7	
	12.30— 1 00	38	5	
	1.00— 1.30	30	7	Foggy
	1.30— 2.00	43	7	
	2.00— 2.30	45	8	
	2.30— 3 00	45	0	
	3.00— 3 32	34	3	
	4 hours 32 min.	295	44	

Aug. 12	Time	Perseids	Others	Notes
	11.00—11.42	24	12	
	11.42—12.10	21	5	
	12.10—12.50	28	4	
	12.50— 1.21	22	3	
	1.21— 1.57	24	11	
	1.57— 2.24	22	12	
	2 24— 2.55	30	12	
	2.55— 3.13	14	0	
	4 hours 13 min.	185	59	
	Total	485	103	

According to Magnitudes.

—4	—3	—2	—1	0	1	2	3	4	5	6
1	0	3	6	57	55	60	70	38	38	157

Number 197 on August 11th was bright enough to light up trees and farm like moon-light; it had a vivid green trail which lasted sixteen seconds and drifted S. W. 76 Perseids had well marked trails, and others left faint ones. There were numerous faint Perseids, too faint to be easily seen with the naked eye. An active shower of meteors without trails gave some very bright meteors throughout the 11th and 12th from a radiant near β Andromeda, and another in Cygnus was active. The maximum must have occurred between 2 or 3 (14 or 15) hours in the morning of the 11th of August, for 89 were seen in 60 minutes, and as many as 12 were seen between 2.35 and 2.36.

ROBERT M. DOLE.

Noridgerock, Maine.

Brilliant Meteor.—On October 3, I held my regular weekly evening session of my Astronomy class in the dome at the top of our high school. I was pointing out to the class the constellation Capricornus, when suddenly there appeared, at about 8:20 standard time, a brilliant meteor which called forth a chorus of exclamations of admiration from thirty throats. It appeared first quite close to Fomalhaut and moved in a northwesterly direction nearly parallel with the horizon for three or four seconds, when it apparently burst, or separated into several different portions, each one of which continued in the same direction for perhaps two seconds, when the downward curve toward the Earth became very pronounced, and it soon after entirely disappeared. At first it appeared whitish, but as it separated the prevailing color

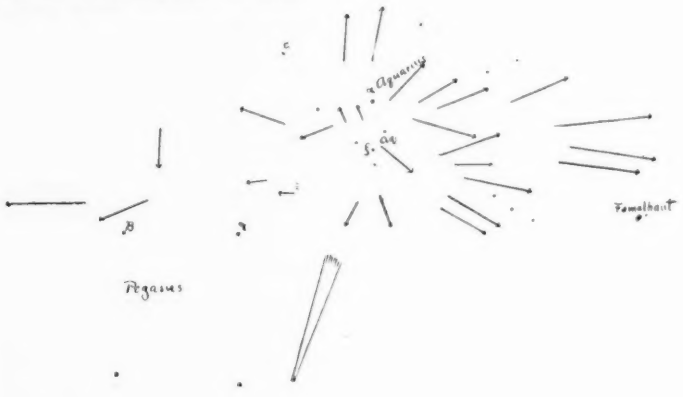
was green. Only once before have I seen anything like it. About six years ago I saw one that burst just like a sky rocket, but on account of houses and trees I could make no observations that would be a basis for reliable data.

G. I. HOPKINS.

Instructor in Math. and Astronomy. Manchester, N. H.

Meteors on May 6.—An article in the Aug.-Sept. P. A. under the caption "Meteors from Halley's Comet" has suggested that perhaps some observations of meteors, made at this place might be of interest.

On the morning of May 6, from 3 to 5 L. M. T., there was a fine display of meteors radiating from ζ Aquarii, 27 being observed and plotted. The diagram is inclosed. There was no doubt that many more might have been seen had not the dawn appeared. On May 9, from 4:30 to 5 A. M., 7 meteors from the same radiant were seen.



METEORS ON MAY 6th.

It was thought that these meteors were related to Halley's comet, until the list of meteor showers in P. A. page 49 was consulted, where a shower was given for May 1 to 6, with radiant point 22h.5 R. A. and —2° Dec., which proved to be identical with the radiant of the shower described above. Furthermore, the position of the radiant of the meteors expected from Halley's comet, as given in P. A., page 306, was considerably different, R. A. 22h 58.5m and Dec. 3° 14′.

GEORGE HURTNELL.

Porto Rico Magnetic Observatory,
Vieques, P. R. Aug. 15, 1910.

Telescopic Meteor.—A rather bright, rapidly moving meteor, which appeared as a streak of light, was seen to traverse the field of my 3-inch refractor obliquely, while observing β Serpentis, at approximately, Aug. 5d 8h 56m C. S. T.

FREDERIC C. LEONARD.

Berlamont, Mich.

Sun Spot Observations.—I had last observed a largish group of 5 Sun-spots on August 19th at 5 P. M. The next morning I could find no trace of them; but at or near their position there seemed to be considerable faculic disturbance. The spots were not so close to the limb of the Sun as to become invisible for that reason, and the definition on the 20th was very good, so I can only imagine that there was an out-burst of hydrogen or calcium vapor which obliterated the group. In fact during all my observations, they had been surrounded by numerous faculic clouds and on August 16th at 4 P. M., and on my last observation I thought the two largest were "bridged".

The time given above is Local Standard time, 116 minutes after Greenwich and it has occurred to me that owing to the ten hours difference in time between California and here, the Mount Wilson Observatory may have seen the actual change. It would be interesting to know if anything exceptional was recorded on plates exposed late on the 19th.

Instrument used 3½″. Refractor: focal length about 48 inches.
Powers 5/8, 1/3, 1/5.

C. E. S. PALMER.
Vice Consul.

Dardanelles, Turkey in Asia.

Miscellaneous Observations.—While in a good atmosphere this summer at Berlamont, Mich., with my three-inch Mogey refractor, several observations were made, which I communicate to POPULAR ASTRONOMY.

An observation of the colors of the satellites of Jupiter was made on July 7. The following results were obtained with powers 28 and 55.

I. Slightly pink.
II. Very slightly bluish.
III. Delicately pinkish, less than I.
IV. Of a slightly steel color.

The Sun was observed through a mist, (without shade), at approximately: 1910, July 3^d 6^h 20^m.

A large spot was observed, the first good one which I had observed since May 18. It was large, irregularly circular, and had a large penumbra. The spot was visible through the 1¼-inch finder as a minute, black disc.

The large sun spot of August 10 was found to be very complex in nature with an extensive penumbra; it was surrounded by many smaller spots.

The tenth-magnitude companion of Vega was seen without difficulty a number of times with power 28.

FREDERIC C. LEONARD.

Leonard Observatory,
Madison Pk., Chicago.
August 31, 1910.

Observation of an Aurora in Kennebunk Beach, Me.—On August 28th, 1910, there appeared a very queer phenomenon. I observed this carefully. It was, as I believe, an auroral arch, extending from east to west.

The evening was quite cloudy at 8:00 P. M., but as there was a strong wind, the clouds blew rapidly off. Through the clouds could be seen snatches of an Aurora Borealis, which filled up the north.

At 8:30 P. M. as the clouds had blown away, I took out my 3-inch refractor and began an observation of certain double stars. One of the first stars was Vega. On turning the telescope upon it I saw with the naked eye, something which looked like a mist and which crossed the Milky Way and made

a complete arch across the sky. I immediately supposed this to be a part of the aurora and took a few notes on it. There were at first, two streams but later both merged into one. The ends of the arch could not be seen on account of the haze. The arch terminated on one side in due east, and on the other in due west. It resembled the Milky Way very much. At 9:00 P. M. there was scarcely a trace of an arch left. It was seen by a great many people near.

HORACE C. LEVINSON.

Leonard Observatory,
Madison Park, Chicago.

ADDITIONAL NOTE ON QUESTION 3.

The rate at which a star is approaching or receding from the Earth, or more accurately, the rate at which the distance between the Earth and a given star is changing, for the Earth's motion is a factor in that change, is determined, as is well known, by the displacement in the lines of the spectrum. It cannot be stated definitely that a given displacement indicates a certain number of miles per second, for the amount of displacement is dependent upon the instrument by which the spectrum is obtained. However, the relative displacement does indicate a definite change in the wave length and hence in the rate of approach or recession of the star.

The formula by which the rate is determined is $\alpha = \frac{(\lambda_1 - \lambda)v}{\lambda}$, where α is the velocity of the star, v the velocity of light, λ the wave length of the ray and λ_1 the wavelength of the ray produced by the motions. For example the difference of the wave lengths of the two D lines according to Rowland's table is nearly six millionths of a millimeter. A displacement of a line equal to one fourth the distance between these two D lines, which amount of displacement could be easily detected and measured, would indicate a factor of 1.5 millionths of a millimeter for $\lambda_1 - \lambda$ in the formula above, and supposing the line whose displacement is measured to have a wave length of 4865 millionths of a millimeter, we have by the formula for the velocity of the star, using 186000 miles per second as the velocity of light, about 57 miles per second. If the displacement is in the opposite direction the sign of $\lambda_1 - \lambda$ would change, and consequently the sign of α also.

QUESTION 6. How are the quantities log r and log Δ, which appear in the Ephemeris of a comet, obtained, and how are they used?

ANSWER TO QUESTION 6. The quantities log r and log Δ that appear in the Ephemeris of a comet, Halley's for example, are respectively the distance from the comet to the Sun, and from the comet to the Earth, in terms of the mean distance from the Earth to the Sun, which is known as the astronomical unit. The determination of these quantities requires the use of numerous auxiliary quantities. As a matter of fact, for the figures given in POPULAR ASTRONOMY for these values for Halley's Comet, after taking the elements of the comet's orbit as known, twenty-six quantities were necessary to determine log r and thirty more for the determination of log Δ. From these quantities, in the process, the right ascension and declinations also were found. Various formulae might be used for determining these values but none would essentially shorten the work or lessen the labor.

These are usually the ultimate quantities desired though they may be used as the basis for determining the varying brightness of the comet, since its brightness depends directly upon the two distances which they represent.

GENERAL NOTES.

Owing to an extraordinary sale, No's 156, June-July 1908; 161, January 1910; 169, November 1909; 170, December 1909, are out of our files. Requests for these numbers have not been numerous enough to warrant the reprinting of any of the issues, but still a number of our subscribers need them to complete their files of POPULAR ASTRONOMY. If any of our readers, therefore, have made all the use they care to of these numbers, and care to dispose of them, we should be very glad to buy them back at the rate of 30 cents a copy.

Dr. Robert D. Baker, formerly assistant in the Allegheny Observatory, has been appointed Acting Assistant Professor of Astronomy at Brown University.

Phoebe Stewart Brashear.—It is with deep regret that we record the death of Phoebe Stewart Brashear, wife of Dr. John A. Brashear, at her summer home in Canada, on September 23, after a painful illness, lasting for many years. In these modern times we are not much disposed to giving women of real worth the respect and credit they deserve, but call those distinguished who pose in public as reformers, or as possessors of great wealth, and thoughtlessly pass by those who are doing real work, work that will last.

During their early married life, Mrs. Brashear acted as Dr. Brashear's assistant in his optical work and therein won real distinction in the scientific world. Later, when Dr. Brashear's activities were called into the broader fields of education and philanthrophy, Mrs. Brashear contributed in no small degree toward his success by her unfailing tact and good humor, and above all by her noble character.

The Eleventh Annual Meeting of the Astronomical and Astrophysical Society of America.

FRANK SCHLESINGER, Editor for the Meeting.

The Eleventh Annual Meeting of the Astronomical and Astrophysical Society of America was held at Harvard College, Observatory, Cambridge, Mass., on August 17, 18 and 19. The Society was welcomed to Cambridge by Professor E. C. Pickering, both in his capacity as President and as director of the Observatory. Among those present were more than a score of foreign astronomers and physicists, who had come to this country for the purpose of attending this meeting and later that of the International Union for Coöperation in Solar Research at Mount Wilson in California. The list of those in attendance is as follows: Miss Allen, Miss Breslin, Miss Cannon, Miss Carpenter, Miss F. Cushman, Mrs. Fleming, Miss Harwood, Miss Hayes, Miss Leavitt, Miss Leland, Miss O'Reilly, Miss Walker, Miss Waterbury, Mrs. Whiten, Miss Whiting, and Messrs. Apple, Archer, Backlund, Bailey, Barton, Bell, Belopolsky, L. Brown, L. Campbell, Cirera, Coit, Comstock, Cortie, Cotton, Dinwiddie, C. L. Doolittle, Douglass, Dugan, Duncan, Dyson, Edwards, Eichelberger, Fabry, Fisher, Fowler, Gimenez, Hepperger, Hills, Humphreys, Hunt, Hussey,

E. S. King, Larmor, C. Lundin, C. A. R. Lundin, Manson, Metcalf, Milham, D. C. Miller, S. A. Mitchell, Newall, Parkhurst, Pierce, Peters, E. C. Pickering, W. H. Pickering, Plaskett, J. M. Poor, Pringsheim, Ricco, Roe, Rotch, Russell, Rydberg, Schwarzchild, Schlesinger, Skinner, Stebbins, Stetson, Turner, Updegraff, Upton, Very, Wendell, Whitman, Willson, Wolfer, W. L. Wright.

The following persons were elected to membership: Miss Leah Brown Allen, Wellesley; Professor A. T. C. Apple, Lancaster; Father Peter Archer, S. J., Georgetown University; Dr. Oskar Backlund, Pulkowa, Russia; Miss Louise Brown, Wellesley, Mass.; Professor Robert E. Bruce, Boston University; Mr. A. J. Champreux, Berkeley; Professor Wilbur A. Coit, Acadia University, Wolfville, N. S.; Professor A. E. Douglass, University of Arizona; Dr. J. C. Duncan, Harvard University; Mr. F. W. Dyson, Royal Observatory, Greenwich, England; Mr. Sturla Einarsson, Berkeley, California; Mr. Charles Grosjean, Omaha, Nebraska; Miss Margaret Harwood, Littleton, Mass.; Miss Ellen Hayes, Wellesley, Mass.; Professor Josef v. Hepperger, Vienna, Austria; Mr. Charles John Hudson, Clinton, Mass.; Miss Jennie B. Lasby, Pasadena, Cal.; Mr. C. A. Robert Lundin, Jr., Cambridgeport, Mass.; Mr. Nutting, Washington, D. C.; Mr. W. Meyer, Berkeley, Cal.; Professor Willis Milham, Williamstown, Mass.; Miss Mary Proctor, New York City; Mr. R. F. Sanford, Mt. Hamilton, Cal.; Professor Karl Schwarzchild, Potsdam, Germany; Mr. Elihu Thomson, Swampscott, Mass.; Professor H. H. Turner, Oxford, England; Mr. Percy F. Whisler, Urbana, Ill.

It will be noticed that this list contains the names of several foreign astronomers; this innovation is likely to prove of great importance to the society and it is hoped that the coöperation of other foreign astronomers will be secured in the near future.

Most of the sessions were as usual devoted to the reading of papers, but time was found for several delightful excursions to points of scientific interest in the neighborhood; thus on the afternoon of August 17, a visit was paid to the Meteorological Observatory at Blue Hill, where Director Rotch exhibited the equipment of the observatory and explained its work, Visits to the Astronomical Laboratories of Harvard College and of Wellesley College on August 18 and 19 were of great interest, especially to those who are engaged in teaching astronomy.

The following is a complete list of papers read at the meeting, abstracts of which will appear in *Science* at an early date:

1. F. W. Very. An Independent Method of Determining the Extratelluric Solar Radiation.
2. Joel. H. Metcalf. A New Sixteen and one-fourth-inch Doublet.
3. H. H. Turner. The Accuracy of Star Positions Derivable from the Harvard Sky.
4. S. A. Mitchell. An Interesting Spectroscopic Binary, 96 Herculis.
5. W. S. Eichelberger. Publications of the U. S. Naval Observatory.
6. H. N. Russell. On the Determination of the Elements of Algol Variables.
7. Raymond S. Dugan. On the Light Curve of RT Persei.
8. W. J. Humphreys. Solar Disturbance and Earth Temperature.
9. Leon Campbell. The Progress in Visual Observations of Variable Stars at the Harvard College Observatory.
10. Edwin B. Frost and Oliver J. Lee. Items as to New Spectroscopic Binaries.

11. W. W. Campbell. Some Preliminary Results deduced from the Observed Radial Velocities of Stars.
12. R. H. Curtiss. Note on the System of Algol.
13. J. S. Plaskett. Probable Errors of Radial Velocity Determinations.
14. J. A. Parkhurst. Visual and Photographic Magnitude, Colors and Spectral Types of Stars to Magnitude 7.5 in Zone Between 73°-74° North Declination.
15. Edward S. King. Results from Photographic Photometry.
16. F. W. Dyson. An Instrument for Rapidly Solving Spherical Triangles.
17. Frank Schlesinger and Robert H. Baker. The Eclipsing Variable, η Herculis.
18. Walter S. Adams and Henry G. Gale. The Spectrum of the Chromosphere and the Application to it of Some Recent Laboratory Results.
19. Walter S. Adams and Henry G. Gale. The Spectrum of the Electric Spark Under Pressure.
20. Frank C. Jordan. The Orbit and Spectrum of *o* Persei.
21. S. I. Bailey. The Photometric Magnitude of Eros in 1903.
22. J. Rydberg. Wave-length Formulae for Series of lines in Spectra,
23. Frank Schlesinger. The Rotation of the Sun for Different Substances in the Reversing Layer.
24. Oskar Backlund. Recent Results Concerning Encke's Comet.
25. Henry N. Russell. Some Hints on the Order of Stellar Evolution.
26. Annie J. Cannon. The Spectra of Some Close Double Stars.
27. W. J. Humphreys. Meteorological Observations in Connection with Halley's Comet.
28. S. A. Mitchell. Eclipse Wave-Lengths.
29. N. F. Newall. On the Solar Spectrum: Coneiderations based on Rowland's Tables.
30. H. F. Newall. On the Variation in the Cyanogen Bands at Wave-Length 3883.
31. Henrietta S. Leavitt. A Comparison of Magnitudes of Certain Stars in the Oxford and Potsdam Astrographic Catalogues and in the Cape Photographic Durchmusterung with Magnitude on the Harvard Standard Photographic Scale.
32. Walter S. Adams. Some Results of the Study of the Spectra of Sirius, Procyon and Arcturus with High Dispersion.
33. H. D. Curtis. The Lick Observatory Photographs of Halley's Comet.
34. Ferdinand Ellerman. The Society's Expedition at Hawaii for Photographing Halley's Comet.
35. E. E. Barnard. On the Motion of the Particles in the Tail of Halley's Comet on June 6, 1910.
36. Joel Stebbins. Some Results with a Selenium Photometer.
37. Frederick Slocum. Solar Prominences Photographed with the Rumford Spectroheliograph of the Yerkes Observatory.
38. W. S. Eichelberger. The Division Errors of the 9-inch Transit Circle of the Naval Observatory and the effect upon the Division Errors of Re-filling the Divisions.
39. Walter S. Adams. Note on the Spectrum of the Star D M. + 30°3639.
40. W. H. Pickering. A Unique Perturbation of Neptune.
41. Alfred Fowler. On the Spectrum of Halley's Comet.
42. Jennie B. Lasby. Note on D_3 in the Spectrum of Prominences.
43. F. W. Very. On the Need of Adjustment of the Data of Terrestrial Meteorology and of Solar Radiation, and on the "Best" Value of the "Solar Constant."

The officers elected for the ensuing year are: E. C. Pickering, *President;* G. C. Comstock, *First Vice-president;* W. W. Campbell, *Second Vice-president;* C. L. Doolittle, *Treasurer;* W. J. Humphreys and Frank Schlesinger, *Councillors.*

Most of the readers of POPULAR ASTRONOMY will be aware that there is a bill pending in Congress contemplating the appointment of an astronomer to direct the Naval Observatory, instead of a naval officer as is now the case. This bill was discussed in the meetings of the council as well as in the general sessions and as a result it was unanimously

RESOLVED: That the Astronomical and Astrophysical Society of America, deeming it essential to the success of an astronomical observatory that it should be under the direction of an eminent astronomer, expresses its appreciation of the efforts of the President of the United States to secure at the United States Naval Observatory this condition, which has been found so effective in the great national observatories of other countries.

In response to a cordial invitation from Chief Astronomer King it was decided to hold the next meeting at the Dominion Observatory at Ottawa; this will be at some time in the summer of 1911, the exact date to be fixed later by the executive committee.

Immediately after the close of the meeting a great many of those present started together on the long journey westward for the purpose of attending the Fourth Conference of the Solar Union at Mount Wilson, an interesting account of which by Professor Wilson has appeared in the October number of POPULAR ASTRONOMY.

Not only was the Eleventh Annual Meeting one of the most important in the history of the Society but it was also one of the most delightful; for this the members are indebted to the thoughtful care of Professor Pickering and all the other members of the Harvard Observatory staff; to Professor and Mrs. Willson of the Students' Observatory; to Professor Rotch of the Blue Hill Observatory; and to Miss Whiting and Mrs. Whitin of Wellesley College.

The Atmosphere, Its Characteristics and Dynamics.—A book by F. J. B. Cordiero, under the above title, came to our notice recently. It is published by Spon and Chamberlain, New York. The author, in this book, goes into the composition, extent, motions, and various phenomena of our atmosphere in a thoroughly scientific manner, and presents some very interesting and, in a sense, some new investigations.

On the assumption that the atmosphere cannot become less dense than ether, whose maximum density is taken as $\frac{1}{3} \times 10^{-14}$ that of water, the author arrives at the conclusion that the most probable average of the height of the atmosphere at the equator is sixty seven miles, while at the poles it is only fifty-two miles, since the centrifugal force is not operative as the poles. Some phenomena, such as certain shooting stars, auroras, and the duration of twilight indicate that the atmosphere may extend beyond the limits named.

One chapter is devoted to a discussion of the motions of particles under the influence of the Earth's gravity and affected by the rotation of the Earth on its axis. The results of these forces upon particles are demonstrated mathematically. In the following chapter the results are applied to the atmosphere, and the cause for the currents of atmosphere as they exist, are adequately explained. The author points out the fact, that, were it not for the rotation of the Earth, which gives the east and west components to the winds, there would be such a terrific blast constantly sweeping from the poles to the equator as to render the Earth uninhabitable.

Subsequent chapters are devoted to very interesting descriptions, and explanations of the causes of cyclones and hurricanes. Also other phenomena such as sound, the rainbow, electrical effects and refraction are discussed. The author also points out very clearly the principles and inherent difficulties in the matter of constructing aeroplanes. The book closes with an exposition of the principle of the gyroscope, and a list of some memorable hurricanes, and a chart showing the barometric changes immediately preceding the Porto Rican Hurricane of August 9, 1899. The book is well written and will repay a careful reading of it.